U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF VEGETABLE PATHOLOGY.

Vol. VI. No. 4.

THE JOURNAL OF MYCOLOGY:

DEVOTED ESPECIALLY TO THE STUDY OF FUNGI IN THEIR RELATION TO PLANT DISEASES.

EDITED BY
THE CHIEF OF DIVISION AND HIS ASSISTANTS.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1891.

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VOLUME VI, No. 4. } JOURNAL OF MYCOLOGY. { ISSUED April 30, 1891.

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THE CHIEF OF DIVISION AND HIS ASSISTANTS.

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EXPERIMENTS IN THE TREATMENT OF PLANT DISEASES.

By B. T. GALLOWAY and D. G. FAIRCHILD.

PART II.

TREATMENT OF PEAR LEAF-BLIGHT AND SCAB IN THE ORCHARD.

Dr. W. S. Maxwell's orchard, where these experiments were conducted, is situated near Still Pond, Maryland, in a region known as the Eastern Shore. This region is justly celebrated for its abundant yields of fruit, pears in particular being one of the most profitable crops. Of late years, however, this fruit has suffered greatly from the attacks of two diseases commonly known as leaf-blight and scab. These maladies are not confined to the Eastern Shore. On the contrary, we find them causing more or less damage wherever the pear is grown, so that these remarks are in a measure applicable to the whole country.

The leaf-blight and scab are caused by two very different species of fungi, which have received the rather formidable names of *Entomosporium maculatum*, Lév., and *Fusicladium pirinum*, (Lib.) Fckl., respectively.

The Entomosporium has already been made the subject of some investigations by this Division,* but no work in the line of preventing the injuries of the Fusicladium have, previous to this year, been undertaken. Dr. Maxwell being a heavy loser every season from both the diseases, and having placed his extensive orchards at our disposal, it was decided to carry on the work at his place.

* Circular No. 8, 1889; Bulletin No. 11, 1889.

PEAR LEAF-BLIGHT.*

In the work on this disease an effort was made to throw some light upon the following questions:

I. The relative value, as preventives of the disease, of the Bordeaux mixture, the ammoniacal solution, mixture No. 5,† copper carbonate in suspension, and copper acetate.

II. The number of treatments necessary to obtain the best results at the least expense.

III. The relative value of early and late sprayings.

IV. Cost of each treatment.

The orchard chosen for the work consisted of Bartlett standards, Bartlett dwarfs and Duchess dwarfs, all of which were last year early defoliated by the leaf blight.

Following is a detailed account of the work taken from our field notes:

1. Bordeaux mixture.—*One treatment to two adjacent rows of 54 Bartlett standards.*—The treatment was made May 29, after the foliage was already partially diseased, numerous patches of the fungus being plainly visible on many of the leaves. Forty-four gallons of the mixture were used, costing 92 cents, or 1.7 cents per tree. The labor of preparing and applying was 60 cents, or 1.1 cent per tree, considerably less than in the experiments on a smaller scale.

Results.—The difference between the sprayed and unsprayed rows was very great, the latter appearing almost entirely bare on September 24, while the former were still in full leaf. Had the appliances at hand permitted the topmost branches to be sprayed thoroughly the difference would have been still more striking. It may be well to add here that for the entire work we used a Nixon Little Giant machine provided with 16 feet of hose and a Vermorel nozzle. Two men were required to work this apparatus, one to do the pumping and move the machine from tree to tree, the other to handle the nozzle. The machine did its work quickly and efficiently as is shown by the very small cost of the treatment.

The apparatus as it was used cost somewhere in the neighborhood of $40. We are satisfied, however, that a machine fully as efficient could be constructed by any intelligent person for less than half the above sum. Such a machine, made by us the past season and used in treating nursery stock, consists of a small force pump fastened to a barrel, the latter in turn being seated upon a sled which is drawn by a horse or mule. The machine, provided with 14 feet of hose and a Vermorel nozzle, can be made for about $18. This apparatus requires a horse, a man, and a boy to work it, and while it is an easy matter to spray as

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* *Entomosporium maculatum*, Lév. For an account of the life history of this fungus see Annual Report of the Commissioner of Agriculture, 1888, p. 357.

† Composed of equal parts of ammoniated copper sulphate and sodium carbonate.

rapidly with it as with the Little Giant, experience has shown that in the end it is more expensive on account of the extra labor involved in working it. A machine to be drawn by hand can readily be made, the materials required being a two-wheeled truck, a barrel, a force pump, hose, and Vermorel spraying nozzle. Such an apparatus can be constructed for $14 or $15. The nozzle is provided with a three-fourth inch screw attachment, and instead of the old style degorger we now fit them with the same kind in use on our lance.*

Returning again to a discussion of the experiments:

II. BORDEAUX MIXTURE.—*Three early treatments to five trees of Bartlett dwarfs.*—The sprayings were made on May 5, 16, and 28, sixteen gallons of the mixture being used. It required 35 minutes to do the spraying, and, estimating the labor at $1.50 per day, the cost of it is 17 cents, or 3.4 cents per tree. The cost of the material was 34.7 cents, or 6.93 cents per tree, making the total expense of treating each tree three times, 10.33 cents.

Results.—On October 6 the treated trees were in nearly perfect foliage while the untreated in adjacent rows had dropped most of their leaves.

III. BORDEAUX MIXTURE.—*Three late treatments to five Duchess dwarfs.*—The dates of treatment in this case were May 28, June 23, and July 8. Sixteen and eight-tenths gallons of the mixture, costing 35 cents, were used. The expense for labor was 24 cents, making the total cost of the sprayings 11.8 cents per tree.

Results.—On October 6 the trees still retained a large part of their foliage while the untreated had lost every leaf.

IV. BORDEAUX MIXTURE.—*Six treatments to five Bartlett dwarfs.*—The treatments were made on May 5, 16, and 28, June 10, 23, and July 8. Thirty-six gallons of the mixture were used and 87 minutes were required to do the work, making the cost for the mixture 15.1 cents per tree and the labor 8.7 cents, a total of 23.8 cents per tree.

Results.—The foliage was completely preserved up to the time the frost removed it. It was, however, in no better condition than that in experiments II and III.

V. AMMONIACAL SOLUTION.—*One treatment to two rows of Bartlett standards containing* 54 *trees.*—The treatments in this and the following experiments were made on the same dates as I, II, III, and IV; moreover, all the other conditions were practically the same. Forty-four gallons of the solution, costing 33 cents, were used. The cost of labor in preparing and applying was 45 cents, making the total cost 78 cents, or 1.44 cent per tree.

Results.—The foliage on September 24 was not as well preserved as that of I, but it was much more perfect than that on the untreated trees. On October 8 the leaves had nearly all fallen.

VI. AMMONIACAL SOLUTION.—*Three early treatments to five Bartlett dwarfs.*—Treatments made on the same day as II, 22 gallons of the so-

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* Illustrated in Vol. VI, No. 2, 1890.

lution costing 16.6 cents being used. The expense of application was 28 cents, making a total of 44.6 cents, or 8.92 cents per tree.

Results.—On October 8 the treated trees were in good foliage, while the adjacent untreated trees were leafless.

VII. AMMONIACAL SOLUTION.—*Five late treatments to twelve Duchess dwarfs.*—Treatments made May 28, June 10, and 23, July 8 and 19, 58 gallons of the liquid costing 43.5 cents being used. The cost of labor was 42.5 cents, making a total of 86 cents or practically 7 cents per tree.

Results.—On September 24, the foliage was only partially removed by the disease and the contrast, though not striking was quite apparent. On October 8 the contrast was much more marked.

VIII. AMMONIACAL SOLUTION.—*Six treatments to three trees of Bartlett dwarfs and four of Bartlett standards.*—Dates of treatments as in IV, 67 gallons being used at a cost of 50.2 cents. The cost of application was 58 cents, making a total of $1.08, or 15.4 cents per tree.

Results.—The standards showed the effects earliest and most markedly, but both held their foliage well into October while surrounding unsprayed trees dropped their leaves before the last of August.

IX. MIXTURE NO. 5.—*Six treatments to five trees of Bartlett dwarfs.*—Applications made the same as in IV, 36 gallons, costing 43 cents, being used. The cost of application was 45 cents, making the total expense 17.6 cents per tree.

Results.—The foliage was badly burned and many leaves dropped in consequence, but the leaf-blight was effectively prevented.

X. COPPER ACETATE.—*Three treatments to two Bartlett standards.*—The applications were made May 28, June 23, and July 8, using a solution of 3 ounces of the acetate to 6 gallons of water. Nine gallons of the mixture, costing 8.6 cents, were applied at an expense of 10 cents for spraying. The total cost therefore was 18.6 cents, or 9.3 cents per tree.

Results.—On October 6 the foliage was in a fair state of preservation, while adjacent untreated trees were leafless. No noticeable damage was done to the foliage, only an occasional leaf being injured.

XI. COPPER ACETATE.—*Six treatments to five trees of Bartlett dwarfs.*—Dates of treatment as in No. IV. Forty gallons of fluid were used, 4 gallons of a strong mixture (4 pounds to 22 gallons), and 36 of a modified (12 ounces in 24 gallons) solution, at a total cost of 62 cents, or 12.4 cents per tree. The cost of application amounted to 45 cents, or 9 cents per tree, making the total expense per tree 21.4 cents.

Results.—The leaves were severely injured, many of them falling long before the proper time. There is no doubt as to the fungicidal properties of this preparation; its use, however, can not at present be recommended.

XII. COPPER CARBONATE IN SUSPENSION.—*Six treatments to five trees of Bartlett dwarfs.*—The solution made by mixing 3 ounces of

copper carbonate in 22 gallons of water was applied on the same dates as IV. Forty-three gallons of the solution were used, but after the first two applications, which seemed to have little effect, the strength was doubled. The total cost of the treatments with this preparation was 13.3 cents per tree.

Results.—The disease was in a measure prevented, but the difference between the treated and untreated trees was not worthy consideration.

SUMMARY OF RESULTS.

Before summing up the results it is proper to state that the season was one exceedingly unfavorable for such an experiment, as the disease even on the untreated trees did comparatively little damage. We feel warranted, however, in drawing the following conclusions from the work.

I. The relative value of the preparations used in treating leaf-blight stand in the order named:

Bordeaux mixture.
Ammoniacal solution.
Copper acetate (3 ounces to 6 gallons).
Mixture No. 5.
Copper carbonate in suspension.

The difference between the Bordeaux mixture and the ammoniacal solution is scarcely perceptible, and if the cost is considered the latter stands first.

II. The best results at the least expense were obtained by the *early* treatments. It is well to add here that we do not accept this evidence as conclusive; on the contrary, we are inclined to think that had the disease been severe three treatments would not have been sufficient to hold it in check.

III. Early sprayings are unquestionably better than late ones.

IV. The cost of the various treatments will, in a measure, depend on the kind of spraying apparatus used, the distance from places where chemicals may be obtained at wholesale rates, and skill of the operator. It may safely be put down that for orchards of one thousand or more dwarfs the cost for treating with the Bordeaux mixture need not exceed 2 cents per tree for each application. For standards the cost will reach 3 cents or perhaps a little less.

In treating with the ammoniacal solution, which is the only additional preparation worth considering in this connection, the cost for dwarfs will average in the neighborhood of 1½ cents per tree and for standards 2½ cents.

From one season's work it is of course impossible to draw any definite conclusions as regards the direct benefit to the trees resulting from the treatment. It is reasonable to assume, however, that if the leaves on a tree, and especially a fruit tree, can be made to continue their normal work until frost, they will enable the tree to make a better growth, set more fruit buds, and consequently bear more fruit the

ensuing season than one which loses its foliage in midsummer. There is, however, a more important matter to consider in this connection, and that is the life of the tree itself. We know that in sections where the leaf-blight is severe a tree soon succumbs entirely to the disease. While we have no data bearing on the longevity of treated trees there is no room to doubt that they can at least be made to live their allotted time.

TREATMENT OF PEAR SCAB.*

These experiments were carried on in the same orchards and at the same time as those described in the preceding pages. Owing to the fact, however, that very little fruit set the work was far from satisfactory. At the time of the first treatment the fruit was about half an inch in diameter and stood erect upon the pedicels. The Bordeaux mixture, ammoniacal solution, mixture No. 5, copper carbonate in suspension, and acetate of copper were used, an effort being made in all cases to bring out, if possible, the relative value of the fungicides as preventives of the disease, the effect of early and late sprayings, the relative value of three and six treatments, and the cost of each application. Without going into the details of the work it may be said:

I. That in no case were the sprayings made early enough, as scab spots had already appeared on the fruit when the first applications were made. It was clearly evident that one spraying should have been made when the flowers were beginning to open and another when the fruit was about the size of peas.

II. There was no material difference so far as the amount of scab was concerned between the trees treated early and late and those which received three and six sprayings, respectively. By early here it must be borne in mind that we mean when the fruit was half an inch in diameter.

III. The costs of the treatments were found to be practically the same as those for pear leaf-blight. When one intends to spray for leaf-blight it will be an easy matter to begin earlier and treat the scab at the same time. In spraying for both of these diseases it would be well to make the first application as described above for scab, then follow with additional treatments at intervals of 12 or 15 days until six or seven in all have been made. In the present condition of our knowledge the Bordeaux mixture is the preparation most to be relied upon as effective against both leaf-blight and scab, and at the same time not injurious to the fruit. Should early treatments alone be made the case would be altered.

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* *Fusicladium pirinum,* (Lib.) Fckl.

THE PEACH ROSETTE.

PLATES VIII–XIII.

By ERWIN F. SMITH.

In the first bulletin on peach yellows some account was given of a peculiar peach disease prevalent in Georgia and not visibly associated with fungi. This account was based on correspondence and specimens received through the mails. In some particulars the specimens agreed exactly with yellows. In others they differed somewhat, and I was in doubt what it should be called. A full opportunity to examine it in the fields and orchards of middle Georgia in the summer of 1890 still left me with some doubt. It seems best, therefore, to call it "the peach rosette" until it can be determined whether it is identical with yellows, as now seems probable.

This disease agrees with peach yellows, as already defined, in the following important particulars:

I. On some of the trees winter buds and obscure buds push into diseased, branched growths identical with yellows. All ot the growths would be identical if the shoot-axes were elongated.

II. Winter buds show the same tendency to unfold in summer and autumn. I saw such immature, feeble growths as late as November 6.

III. Part of a tree may be affected while the rest appears normal.

IV. The disease can be communicated to healthy trees by inserting diseased buds. In my inoculations of June 21, sixty per cent of 125 stocks showed symptoms of the disease in four and one-half months.

The disease differs in the following particulars:

I. The entire tree is more apt to be attacked all at once, and the disease is more quickly fatal. Trees often die the first year, and I have not heard of any cases living beyond the second season. What corresponds to the first stage of yellows *seems* to be wanting.

II. On the parts attacked, many obscure buds and all or most of the winter buds push into diseased growths suddenly *in early spring*. The primary shoot-axes grow only an inch or two, but send out many short branches. This gives to each growth a compact tufted form, and to the affected tree a very peculiar appearance unlike anything heretofore described, and much resembling the work of insects. These stunted, green, or yellowish rosettes often form the only foliage of large trees, projecting from the ends of long, naked twigs like leafy galls, or like house leeks tied to the ends of sticks (see Pl. IX).

III. The lower leaves on these tufts or rosettes roll and curl, turn yellow, dry up at the ends and edges, and fall early. They begin to drop before midsummer, and a slight jar shakes them off by the hundred.

IV. On the trunk and base of the main limbs it is rare to find anything more than rosettes, and often these also are wanting, the diseased growths being confined to the extremities of the branches.

V. Diseased trees seldom bear fruit of any sort. Most growers deny that such trees ever bear premature fruit, but one man who has lost two orchards insists that he has seen it. No fruit could be found in Georgia peach orchards in 1890, and this point was necessarily left unsettled

VI. The disease occurs in wild and cultivated plums, to which it is quickly fatal. Thousands of the wild Chickasaw plum (*Prunus Chicasa*) have been killed by it during the last few years. I also saw it in two Japanese varieties—Kelsey and Bhotan—and in one or two American varieties probably derived from *P. Chicasa.*

If this malady is yellows, our definition of that disease must be somewhat modified and enlarged to include the plum or at least certain varieties of it. My previous statements relative to the immunity of the plum were based on observations north of Virginia and had special reference to varieties of *Prunus domestica.*

This disease has been in upper middle Georgia for at least 10 years, and during this time has destroyed whole orchards. With some noteworthy exceptions it has not swept away budded orchards as quickly as the yellows of the North, but it takes some trees every year, and is evidently a dangerous enemy. This is true especially, because of its prevalence in the hardy wild plum which grows everywhere. During my visit I saw the disease in twelve counties: Fulton, Clayton, Campbell, Henry, Spalding, Pike, Meriwether, Coweta, Troup, Talbot, Harris, and Muscogee, and heard of it in ten others: Upson, Monroe, Bibbs, Butts, Jasper, Putnam, Greene, Taliaferro, Morgan, and Oglethorpe. It is widespread and well established in that part of Georgia.

The disease attacks cultivated and neglected orchards, young and old trees, seedlings and budded fruit. If anything, it is more prevalent in thickets and waste places, the edge of forests, and on the borders of streams, or by the wayside, than in orchards. It is not restricted to any special kind of soil or prevented by any method of cultivation. It occurs on the common red clays, on the gray and granitic sandy lands, and on a chocolate-colored, deep, fertile loam, commonly called "mulatto land."

A disease which appears to be identical (see Pls. XI–XIII) occurs also in Kansas. So far as known, it is now present only at Manhattan, and has not yet appeared in the important peach districts of southern and southeastern Kansas.

The attention of the writer was first directed to the disease by Mr. T. C. Wells, who sent specimens in 1889. The malady continued in 1890, when Dr. Kellerman also sent specimens and made inquiries. Later in the year I was able to examine it more carefully in the orchards themselves.

The farm of Mr. Wells is in the Kansas River valley, on a fertile, rolling prairie, about midway between the bottom lands and the limestone hills, *i. e.*, on what is called the "second bottom." The soil is a dark and a very deep loam, gradually shading into a reddish brown,

clay subsoil. In moist seasons this soil yields from 40 to 60 bushels of shelled corn. Apples, plums, grapes, elms, negundos, etc., also grow in it vigorously. The soil must contain plenty of lime, since horizontal, eroded ledges of limestone crop out everywhere on both sides of the Kansas valley for miles and miles.

This orchard of choice budded fruit contained only about two hundred trees, but they had always been thrifty and well cared for. The older trees were 8 to 12 years old and had borne several good crops; the younger (about fifty replants) were 4 to 6 years old and had borne only one crop.

Mr. Wells first noticed this disease in 1889. He says there were no cases in his orchard prior to 1889. That year more than 75 per cent of the trees became affected in whole or in part. The disease appeared in the spring and most of the trees were dead or dying when cut down the following autumn. A very pestilence seemed to have stricken the orchard.

In August, at the time of my visit, only about fifty trees remained. These were replants, 4 to 6 years old, and had been thrifty. Dr. Kellerman and Mr. Swingle carefully examined them in July, 1889, at which date about one-half were healthy. Dr. Kellerman accompanied the writer in an examination and we could then find only two healthy trees. The rest were diseased in the same way as the cases of the previous year—some were dead and the others showed symptoms throughout or on a part of the tree only. All trees which were noted as affected in July, 1889, were dead or dying.

Neighboring orchards were almost as badly affected. Most of these were neglected seedling trees in sod ground. About one hundred cases were also observed in a peach thicket where the struggle for existence was severe. In none of these places could I satisfy myself that the disease had been present more than two seasons, and the question of its origin is exceedingly obscure.

As in Georgia the terminal shoot-axes were developed into tufts all over the tree, but usually these were somewhat less compact. None of the peach trees had developed any luxuriant branched growths on the trunk or base of the main limbs as is common in the yellows of Maryland and Delaware, but the winter buds were pushing in the same way. Last year some of these trees bore fruit, but I could not learn that any of it ripened prematurely. Frequently one-third to two-thirds only of the tree was visibly affected. Occasionally trees would be diseased, dwarfed, and yellow throughout, except one or two small terminal shoots in the top of the tree. These, in striking contrast, bore leaves of normal size and color. This also happens in Maryland and Delaware in ordinary yellows.

This disease was also observed in cultivated plums of the Chickasaw type and in the hard shell almond. I have no hesitation in saying that it is identical with the disease which occurs in Georgia.

This rosette disease resembles yellows very closely, to say the least, and there are transition forms in both States, and growths not distinguishable from genuine yellows. The absence of the prematurely ripened fruit may be due to the suddenness and severity of the attack. The long, dry summer or other climatic peculiarities of these two regions may possibly account for this, and also for certain other symptoms at variance with the yellows as heretofore known and described. These are points to be worked out hereafter.

The disease in Georgia has been erroneously attributed to the attacks of Scolytid beetles. * *Scolytus rugulosus* is common in Georgia, and rather destructive, but in June the mother beetles were only just commencing to burrow into the bark preparatory to depositing their eggs, *while the trees had been affected with this disease for several months.* Moreover, in June there were many diseased trees which had not yet been attacked by a single beetle or had only a few borings. To satisfy myself I examined some of these carefully over every square inch of their surface; cut the bark open in every direction, and examined each one of several thousand rosettes, *e. g.*, the tree figured on Plate IX. In July it was more difficult to find such trees, although not impossible, *e. g.*, on June 30, in company with Mr. Rudolph Œtter, I examined four trees in a middle-aged, seedling orchard near Griffin, Ga., with the following results:

(1) This tree was nearly dead and the rosettes had a droopy look. In a section of one limb, which was not over 1½ inches in diameter and 2 feet long, we found 83 excavations made by *Scolytus rugulosus.* The beetles were present and burrowing in most of these holes, but not yet buried out of sight. The evidence of recent occupation was strong.

The tree probably contained a thousand beetles, but most of them had been at work only a few days. They had bored into the base of many of the rosettes, and this was what gave to the foliage its wilted, drooping appearance. This tree died in July, 1890. It was probably attacked by the rosette disease in 1889.

(2) This tree was diseased in all parts, and did not bear a single full grown leaf or shoot-axis, but the rosettes were still green and fresh. This tree was even more minutely examined than the preceding. In the trunk and main branches there were no beetles, no holes, and no internal borings or chambers. There were also very few injuries on the smaller twigs, the most careful search bringing to light only half a dozen.

(3) This tree contained many beetles. The foliage was wilted and drying up as in No. 1.

(4) This tree was like No. 2 in appearance. It was also like it in being almost completely free from beetles or borings due to them.

No larvæ or pupæ were found in any of the trees.

It is wholly impossible to account for several thousand diseased growths scattered over the whole top of a tree by the slight borings of a few dozen beetles, even admitting their constant presence in the

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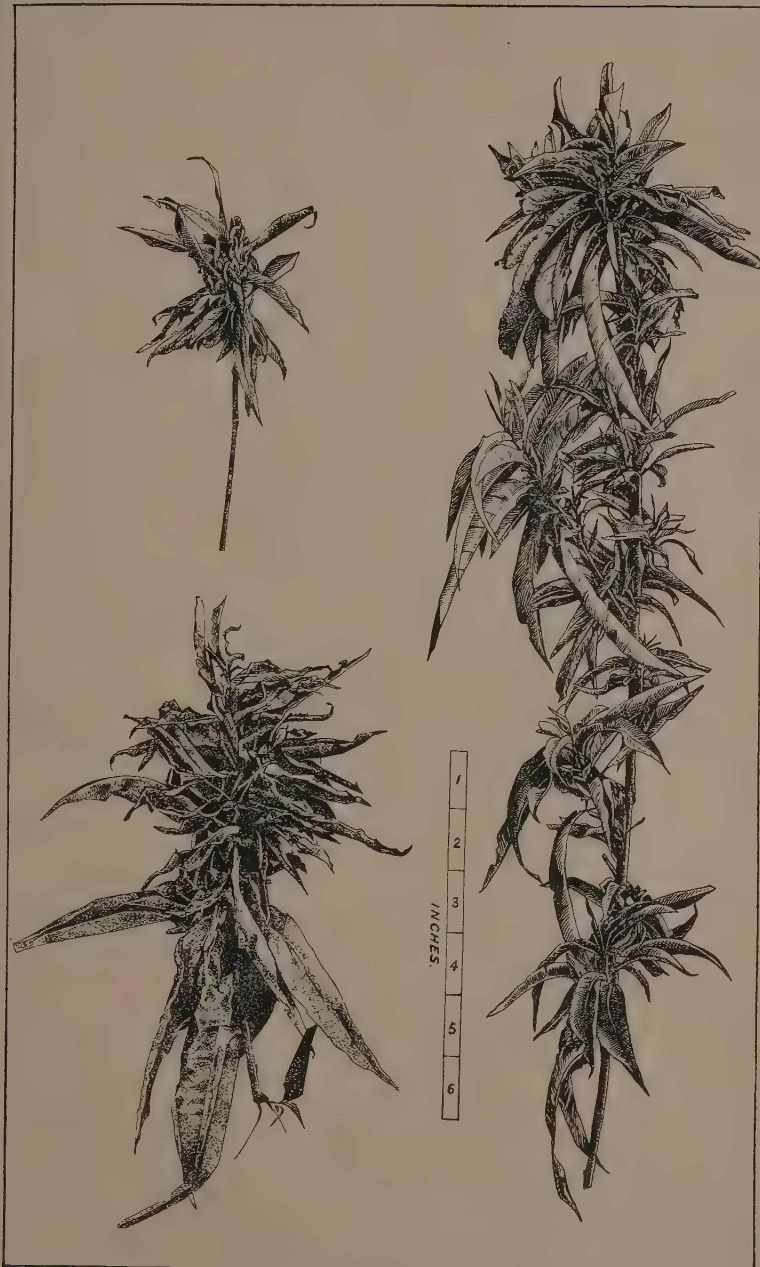
* *Proc. Georgia State Hort. Society*, 1889, pp. 16 and 46.

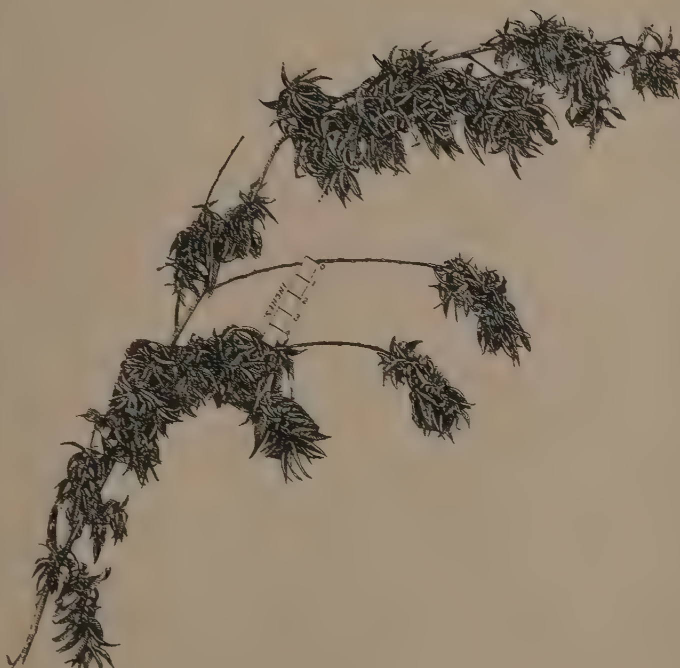
HEALTHY PEACH TREE.—GEORGIA.

THE ROSETTE.—GEORGIA.



THE ROSETTE.—GEORGIA.

THE ROSETTE.—KANSAS.



THE ROSETTE.—KANSAS.

THE ROSETTE.—KANSAS.

early stages of the disease, which is by no means the case. As a rule, beetles of this group prefer sickly trees. Late in the season many such trees were riddled by *Scolytus*, but they did not appear in numbers until June. The time to make such an examination is in the spring when the disease first appears and not in summer or autumn when the trees are nearly dead. In spring, when the cause of this rosette disease is very active, the *Scolytus rugulosus* can do no harm, because it is then undergoing transformations in the trees which were attacked the previous year. Larvæ and pupæ were taken from a number of such trees. They were generally in winding passages in the wood, and were most abundant in some plum trees not suffering from this disease.

Moreover, repeated observations in Kansas during a two-weeks' visit failed to discover a trace of this insect. Neither had the Experiment Station entomologists ever seen it. The probabilities, therefore, are that this species has not yet appeared at Manhattan.

The *Scolytus rugulosus* does not cause this disease, nor do I think it due to any other insect. Whatever be its cause, the disease is evidently increasing, and peach-growers should be on the alert to destroy it as soon as it appears. The affected trees should be dug out and burned as soon as discovered. The contagious nature of the disease is now beyond dispute, and it is not wise to let them remain a single day.

EXPLANATION OF PLATES.

PLATE VIII. Healthy peach tree from an orchard of budded fruit near Griffin, Georgia. Set $2\frac{1}{2}$ years. This tree stood upon cultivated, level, fertile "mulatto land." Photo, June 28, 1890.

PLATE IX. Tree attacked by the rosette—a typical case. This tree stood in the same orchard as VIII and not over 20 feet distant. It was healthy in 1889. Photo, June 28, 1890, at which time it did not bear a single leaf or shoot-axis of normal character. The bark on the trunk of this tree had been injured by a borer (*Ægeria exitiosa*, Say) but over an area not larger than a silver dollar. There were no other injuries by borers; no bruises, and no borings by *Scolytus* anywhere on the trunk or main limbs. To determine the amount of twig injury attributable to *Scolytus*, I examined each one of the several thousand tufted and growing shoot-axes, and all of the internodes, finding three beetles and fifty slight injuries. All these were of recent date, and many did not reach into the cambium. There were no larvæ and no winding passages under the bark. Usually the gnawings were at the base of the tuft on the upper side in the acute angle formed by the shoot and the older stem. These injuries were generally vertical and seldom over one-eighth of an inch long or broad. In no case was a twig of the previous year's growth girdled or so injured as to affect shoots above the boring. The worst injuries amounted simply to the killing of the particular shoot-axis bored into. These had dried up and were easily distinguishable from the uninjured majority. The fact that the dead shoots were nearly as large as the rest showed clearly that the injuries were of recent date, whereas the tree had been diseased throughout for several months, *i. e.*, ever since it began to grow in the spring. The fifty injuries by the beetles were not more serious than would have been a like number of stabs with an awl. Later in the season no doubt the tree might have been full of beetles and larvæ.

PLATE X. Rosettes from a seedling tree near Sunny Side, Georgia. This tree showed symptoms of disease on only about one-half of its branches. On some of the branches the winter buds had germinated, especially toward the upper ends of the shoots. Photo, July 2, 1890.

PLATE XI. Diseased peach tree from the budded orchard of T. C. Wells, Manhattan, Kansas. Much smaller than the average. Healthy in 1889, but now affected in all parts. There were no injuries by borers, root aphides, root knot, or *Scolytus*. The winter buds were germinating on some of the tufts. Photo, August 16, 1890.

PLATE XII. Diseased branch from a seedling tree in the orchard of W. J. Griffing, Manhattan, Kansas. Whole tree affected in the same way. An extreme case of tufting. Photo, August 23, 1890.

PLATE XIII. Diseased branch from a seedling tree in the orchard of W. J. Griffing, Manhattan, Kansas. The whole tree was affected. Photo, August 18, 1890.

TUBERCULOSIS OF THE OLIVE.

PLATES XIV, XV.

By NEWTON B. PIERCE.

During the summer of 1890, I enjoyed the opportunity of meeting, under the most pleasant circumstances, Dr. Luigi Savastano, professor of arboriculture of the Royal High School of Agriculture, at Portici; the latter a beautiful town situated at the base of Vesuvius, on the shores of the Bay of Naples. Dr. Savastano has recently done some excellent work on the tubercle disease of the olive, having conducted several series of experiments with cultures and inoculations which have resulted in clearly demonstrating the bacterial nature of this most interesting malady. These experiments have been carefully repeated by Dr. Fridiano Cavara, of the well-known agricultural school of Pavia, south of Milan. The result has been equally conclusive and interesting. It was my good fortune and pleasure to meet both Drs. Briosi and Cavara of this school, and to have the opportunity of seeing much of their valuable work. The writer was shown an olive tree into which bacilli of the olive tuberculosis had been introduced, and which was showing at the points of infection well-developed tubercles. At its side stood another olive of like size and similarly conditioned, which had been treated in all ways as its companion with the exception that the wounds made by the knife had never received the germs. No signs of a tubercle were to be seen upon this tree. The organisms used in these experiments were from artificial cultures.

During the author's labors in the Mediterranean region, tuberculosis of the olive was encountered at several places and under various conditions. On this account the liberty is taken to append a note or two to a translation of the published account of the concluding experiments of Dr. Savastano.* There is also given a reproduction of figures pub-

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* *Il Bacillo della Tubercolosi dell' Olivo, Nota Suppletiva del dott.* L. Savastano. Roma, 1889.

lished by Drs. Cavara and Briosi, showing the section of a tumor with the location of the bacilli in the tissues, as well as the germs themselves as seen in the stained preparations on the slide. I was shown while at Pavia the preparations from which the sketches were drawn, and will say they are fairly represented in the figures given. To supplement this there have been added figures from my own material and photographs of affected olive branches, showing the location and various stages of the tumors *in situ*.

Dr. Savastano's account of the disease is as follows:

In my study of the tuberculosis of the olive (commonly *scab of the olive*)* I established the presence of a pathogenic microörganism in the tumors, cultivated it, inoculated with it, and obtained by means of it the formation of tumors. I explained that owing to circumstances over which I had no control I was unable to complete the study of this microörganism with the thoroughness which bacteriology requires. Having obtained the means for undertaking the researches in the bacteriological laboratory of the Zoölogical Station at Naples,† I have resumed the study which I was reluctantly obliged to leave incomplete.

The characteristics of the pathogenic microörganism of the tuberculosis of the olive are the following: The cultures are made in a way to avoid error only when incipient tumors are used. If they are made from old tumors it is necessary to take the inner part of the cambium zone. Taking the external part, only the microörganisms of the air are found.

This microörganism is a Bacillus of medium size: length three to four times its width; it is isolated, but is sometimes joined into chains: the extremities are slightly rounded off. In drops of bouillon it has a distinct movement. The colony has a variable form, from round to oval, with a well-defined margin. In the beginning it is uniformly pointed; later it forms one or two peripheral circles. It is whitish by reflected light, cedar-color by transmitted light. The bacillus lives well in ordinary culture media (bouillon, potato, gelatine, agar). I have attempted to make another medium for culture with material taken from the olive. It did not prove very suitable, and the preceding media are preferred. Gelatine does not liquefy in our climate from January to April; from May to June it liquefies slowly. The culture has a relatively long life; cultures made in March were still living in June. In short, degeneration begins in about 3 months. The bacillus stains very well with simple aniline colors. I have not been able to establish a distinct spore formation. The method of double staining does not succeed very well, because the cell wall takes up the aniline colors more easily and gives them up with greater difficulty than the microörganisms.

On the potato it lives very well and develops rapidly: the colonies are at first like so many small round dots, translucent straw-color, which, as they develop, form on the surface of the potato a uniform stratum, translucent, and of a deeper color. The bacillus acquires greater dimensions.

On the gelatine plates it lives very well, with characters and forms as above indicated. In tubes of gelatine *a becco* the culture presents the appearance of a uniform stratum, whitish, the margin finely bilobed, reminding one of the margin of a leaf, the whole culture taking the form of a spatulate leaf. It is slightly dichroic.

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* *Tubercolosi, iperplasie e tumori dell' olivo. I. II. Memoria.* Annuario R. Scuola Sup. d'Agricoltura in Portici, Vol. v, fasc. 4, 1887.

† The equipment for bacteriological work in the Naples Station has been but recently added, we believe. The station now has the facilities for doing good work of this class. Mr. H. Linden, in charge of the station, who has our thanks for courtesies extended during our stay at Naples, fully convinced us, after a careful inspection of the laboratories and general accommodations of the institution, of the desirability of more American students reaping the benefit of the advantages there offered.—N. B. P.

In tubes of agar *a becco* the culture is indentical with the preceding, the margin is less bilobed.

The culture by needle in gelatine presents a uniform, transparent, finely pointed appearance. On the surface of the meniscus the form is irregularly rounded with a finely lobed margin as in the preceding.

In the different materials taken from the olives of Puglia, Calabria, the Vesuvian region, and the Sorrentine peninsula, I have demonstrated in each case the same microörganism in the cultures.

In tumors which had been gathered about a year the Bacillus had been destroyed.

In the cortical tubercles and in their miliary form I have demonstrated the same Bacillus. I have performed three series of inoculation experiments. I have practiced the same method of inoculation which I had before adopted.

Series I. Inoculation of pure cultures in olive plants.—The plants used were all grown from seed, some were raised by myself, others were given me by Signor R. Pecori, of Florence, from his establishment. The plants were taken from seed and not from cuttings, to avoid heredity from the mother plant which might be infected.

The inoculations were made April 27 of the current year. By the 1st of June the tumors were already evident, and by the 1st of July were much developed. The controls have not given signs of tumors. These results are the confirmation of those obtained roughly by me and with impure cultures in 1887. I am able to conclude that *the disease of the tuberculosis of the olive* (commonly scab) *may be produced by a specific pathogenic Bacillus which I name Bacillus oleæ-tuberculosis*, understanding the tubercle in the sense of botanical pathology.

Series II. Inoculations of the Bacillus in other plants.—The conditions of inoculation are identical with the preceding and on the same day in the following plants: peach, plum, apricot, grape, fig, pear, apple, bitter orange, lemon, rose, *Abies excelsa*, *A. pectinata*, *Cedrus Libani*. Till now (July 30) I do not see the least sign of a tubercle; the wounds are perfectly closed and healed. I am able to conclude from this that *these bacilli are not able to produce the same pathological effects in the plants indicated.*

Series III. Inoculations of other microörganisms in olive plants.—With the identical conditions preceding I inoculated into olive plants the following microörganisms which I am studying in the said Zoölogical Station: (1) A bacillus obtained in small tubercular swellings of the plum; (2) a second bacillus obtained as the preceding; (3) a bacillus found in the gums of citrous plants; (4) one of the bacilli of the pus of the citrous plants; (5) a bacillus of the cancer of the vine. Not one of the many inoculations has produced a tumor. Could this be done the tuberculosis might be produced by any microörganism whatever. *This third series of experiments indicates much more certainly the pathogenic power of the Bacillus of the tuberculosis of the olive.*

General observations.—The tubercle of the olive is an excrescence upon the limb of the tree which might pardonably be at first mistaken for an insect gall. These excrescences or tumors are quite variable in size, probably most of them are mature before reaching an inch in diameter, but some become large coarse knots. Many branches cease to grow, in whole or in part, beyond the tubercle, after the latter has become partially developed. Some branches become stunted while others die entirely toward the end. Hence the growth of the tubercle is largely limited by the vigor and life of the limb bearing it.

Dr. Savastano says* that the tubercles occur upon branches from 1 to 15 years of age. In forming, the tubercle commonly takes its origin quite near the cambium zone, though more frequently the center of bacteria begins to form in the liber portions of the fibro vascular bundles. To the unaided eye the forming center appears like a very small

* *Comptes Rendus.* Paris. T. CIII, p. 1144.

transparent spot, which, under magnification of 1,000 diameters shows the colony of bacteria already formed. There is now manifest about the colony a hypertrophy of the elements which may become more or less profoundly altered. As the colony enlarges the hypertrophy increases. The tubercle grows until in time it cracks through the exterior bark. When the tubercle is formed its growth is not usually arrested, but it continues to increase more or less in size each year, often attaining a diameter of 0.01 to 0.02 meter (two to four fifths of an inch). The tubercle is formed in the spring; during the heat of the summer the hypertrophy is arrested, but the colony of bacteria increases considerably. Then, during the autumn renewal of growth the hypertrophy begins again.

The irritation or stimulation caused by the presence of the bacillus, so far as our observations have extended, produces only a localized growth of tissue. There is scarcely more evidence of a general or constitutional disorder of the sap of the tree affected than is produced in the oak under the action of the Cynipidæ. The stimulation of the affected branch scarcely extends beyond the node or internode where the swelling occurs. The impoverishing action of this growth, however, is often plainly observed on the entire twig beyond the tubercle. The limb sometimes shows a marked reduction in diameter, though perhaps green and healthy in other respects. In a majority of cases the enlargement only involves one side of the branch. It is not uncommon to find two centers of inoculation producing coalescing tubercles; but the distinction of origin is rarely lost. So far as I am aware progressive death of the limb below the point of infection, as is the case with pear-blight, never occurs. There is no analogous and general pathogenic degeneration of the tissues as found in limbs affected by that disease.

From some of my first observations, where I found the tubercle developing at the node of the limb, I thought it likely that inoculation had been effected by means of the axillary buds. Later, however, many tubercles were noticed, located upon internodes, and having no connection with the leaf axil. This has left the method of entrance of the Bacillus obscured, unless, perchance, it be through the growing point, and continued growth has left it within the internode or at the node. This explanation seems more probable than that the organism has directly penetrated the bark of the branch. It is also rather indorsed than otherwise by the fact that whenever mechanical injury has occurred to the bark, laying bare the cambium tissue, the tumors are often unusually numerous. They are most common where a bud or leaf or branch has been broken off, or where some injury or splitting of the branch has occurred. In one case observed, where a branch had been split for a few inches, three distinct centers of inoculation were seen at the edge of the ruptured bark within the distance of 2 inches. Undoubtedly, however, inoculation may occur through slight cracking or other injury of the bark.

The local and general distribution of tuberculosis of the olive is peculiar and interesting. There is no such sweeping and complete infection accomplished by this disease as is the case in the spread of many germ diseases. I was told that near Genoa the disease is very common and quite destructive. At Rome I visited an olive grove near Colonna, some 16 miles from the city and north of the Alban Hills. In company with Professor Cuboni I made careful search for this disease, and only obtained a single tumor from a considerable number of trees examined. Another case somewhat similar occurred at Portici. The agricultural school building there was formerly a royal residence, and retains back of it an extensive park which was fitted up in connection with the residence or palace. Here is an extensive olive grove. Dr. Savastano, his assistant, and myself searched through this grove for some time for tubercles, only finding, at last, a few on the upper limbs of a single tree. At Cancello, some 12 to 15 miles north of Vesuvius, is a large olive grove covering the hills at that place. I here spent several hours in a fruitless search for this disease; at Palma, about an equal distance southeast of Cancello, the trees were quite badly infected. Upon a single small branch (the one shown on Plate XIV) I counted not less than twenty-nine swellings. All about the hills north of Messina, Sicily, especially in the neighborhood of Faro, the olives are badly infected, and in one or two cases nearly the entire top of the infected tree was ruined. In the province of Syracuse, where olives are largely grown, and where they are very old and thrifty,* no signs of this disease were seen. At Palermo, northwest Sicily, it was again encountered, and noted as being the worst phase of the disease seen up to that time. In Algeria I did not encounter the trouble, but have little doubt of its existence there, as well as in all of the Mediterranean olive-growing countries. It exists in France. My observations show me that the disease is very irregular in its distribution. One olive grove may be free from it, or nearly so, while another not far distant may be badly infected. One tree in a grove may be, apparently, the only one infected. Again, the disease may be localized upon one portion of a single tree. Probably nothing short of a clear understanding of the means of distribution and infection will explain these facts.

Careful attention to the excision of all affected branches is apparently all that is required to keep this affection from spreading and doing serious damage.

As the olive industry is becoming one of importance on the Pacific coast, it is well that those interested should have the facts relative to the various enemies of that industry placed before them. In this way they may become familiar with those diseases not yet affecting their groves, and may take steps which shall prove an ounce of prevention worth more than a pound of cure.

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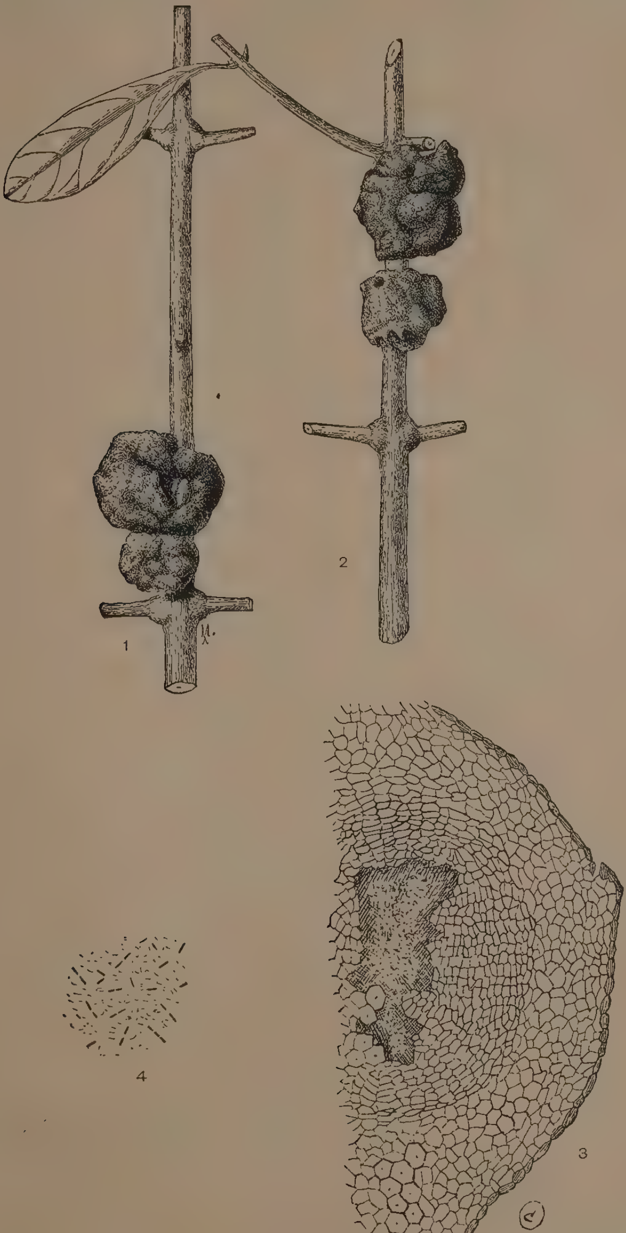
* Near Floridia, some 14 miles west of Syracuse, I found one magnificent old olive tree in perfect health, which measured 13 feet in diameter at the ground and 10 feet in diameter at 3 feet above the ground.

PIERCE ON OLIVE TUBERCULOSIS.



Pierce on Olive Tuberculosis.

EXPLANATION OF PLATES.

OLIVE TUBERCULOSIS.

PLATE XIV. Olive branch 18 inches long, bearing 29 tubercles, only part of which are seen in the plate, and none are fully matured. Several of the tubercles have but recently broken through the bark of the branch. This branch was cut July 29, 1890, from a badly infected olive tree growing in an old grove two miles south of Palma, in the province of Naples, Italy. Photograph of fresh material.

PLATE XV. FIG. 1. Well-matured olive tubercles of natural size, showing the usual ruptured condition of the top. The rupturing is preceded by a slight pitting at the surface, as shown in the lower tumor. Material from near Genoa, Italy.

2. Olive tumors from the same source as those of Fig. 1. The lower tumor shows an opening through which some insect has escaped, which inhabits the old tumor, and which may assist in spreading the disease.

3. Section through a tumor. Shows the hypertrophy of the tissue and the degeneration at the central part of the tumor where the bacilli are situated. After Briosi and Cavara.

4. *Bacillus oleæ* (Arcangeli), Trevisan. From figures of stained slide preparations by Briosi and Cavara. I have seen the original preparations given in Figs. 3 and 4.

RECENT INVESTIGATIONS OF SMUT FUNGI AND SMUT DISEASES.

AN ADDRESS DELIVERED BEFORE THE SOCIETY OF AGRICULTURISTS OF BERLIN, FEBRUARY 17, 1888.

By Dr. OSKAR BREFELD.

Full Professor of Botany in Münster in W.

Translated from *Nachrichten aus dem Klub der Landwirthe zu Berlin*, Nos. 220–222, by Erwin F. Smith.

(*Continued from p. 71.*)

For the solution of the first question some important data have been pointed out already in speaking of the mode of infection, to wit, the application of the germs and their penetration into the host. From the results of the first five series of experiments it is evident that the period of receptivity in the seedlings is very transitory. The slower this stage of growth the more probable it is that the germ which has penetrated at the right spot will actually reach the growing point in the given time; and this must be reached if the nascent blossoms and fruits (the subsequent location of the smut beds) are to become smutty. On the contrary, the more rapid this stage of growth the less must be the probability that the germ can reach the growing point in the short time before the seedling begins to elongate. And from this point of view the most extreme case would be when a very greatly hastened development of all seedlings altogether prevented the passage of the penetrated germ into the growing point; in this case, in spite of all penetrated germs, the appearance of the smut diseases would be impossible.

Now, in the first place, the rate of development of seedlings may be very different for different kinds of plants, and in general it may well depend on this whether they are or are not susceptible to smut diseases;* furthermore, in the particular forms which are attacked, it may fluctuate noticeably according as they belong to special races or sorts, and consequently these are more or less receptive. But more than all this, in particular individuals of the same species of cultivated plant a somewhat hastened or retarded development during germination will assert itself in smaller fluctuations, which here nevertheless may be decisive. For this reason it seems only natural that the receptivity toward smut fungi will be individually different, that consequently in the same material, under otherwise similar conditions, only a portion of the host plants will become smutty, as was actually the case in our experiments. The fungous germs certainly penetrated into every seedling, but the growing point was not reached in all cases, and only those finally became smutty in which it was reached. To what extent the temperature may influence the result I will only point out briefly. Warmth hastens development, but whether it acts equally on the growth of the seedlings and on the fungous germs in them had to be decided by infection experiments conducted at higher temperatures than those here described. These supplementary experiments showed that when seedlings, as in I, were infected at 15 degrees C. only 3 per cent of the plants became smutty, while at still higher temperatures only 1 to 2 per cent appeared or no smutty plants whatever.† The higher temperature, therefore, hastens the growth of the seedling proportionately more than that of the fungous germ, and thus hinders the development of smut in the plants.

It now remains to ascertain the reasons why, in all the series of experiments, not a single one of the infected barley seedlings produced a smutty plant. In the first place, it is self-evident that the negative results with the barley can not change in the least the positive results with the oats. On the other hand, without further inquiry, the explanations given for the incomplete sickening of the oat plants are by no means to be urged

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* From the sum of the experiments and the preceding observations it follows naturally *that the simple penetration of the germ into the host plants*, on which the school of De Bary laid such stress, is not decisive for the appearance of smut diseases. But beyond this, I have by special experiments determined *that the most diverse smut germs can penetrate into all sorts of plants, which are never attacked by smuts*, consequently, the penetration of the germs only proves an unimportant detail. The results of these many experiments establish the accuracy of the views and conjectures on parasitism and the way it may occur in nature, of which I have already spoken in *Den Brandpilzen* I, p. 26–29.

† In the paniculate heads of the oat, sound spikelets sometimes occur at the tip of a panicle while the lower spikelets are destroyed by smut. In such cases the penetrated smut germs had not reached the uppermost point of the inflorescence when the elongation began; therefore these remained sound while the lower were attacked by smut. The correctness of this interpretation of the interesting discovery is shown by the fact that in such partially diseased panicles the *uppermost portions without exception are sound and the lower are diseased*, but never do the upper become diseased while the lower remain sound.

for the entire immunity from smut observed in the infection experiments with barley, and especially because barley in the field is more frequently attacked by the dusty smut than oats. The results remained a complete enigma for three long years. But then this case also was explained as naturally as imaginable.

I received accidentally from Yokohama, through Chief Brigade Physician, Dr. Kügler, some smutty spikes of barley. It occurred to me that it was worth while to see whether the dusty smut on the barley in Japan agreed exactly with the dusty smut in Germany. I therefore sowed its spores, which in shape and size were indistinguishable from our own dusty smut, in nutrient solutions. Here it came to pass that in the universal germination of the smut spores into a promycelium *no conidia* were produced upon the latter, although they appear in countless numbers, as we know, in the spore germination of our own dusty smut. The promycelium afterwards branched in the same way, and just as abundantly, as any mold, but in a purely vegetative manner, without any formation of conidia.

In this manner mycelial masses were produced of such dimensions as can scarcely be derived from Saprophytes upon slides. As soon as the nutrient solutions were exhausted the remotest threads grew out stolonlike, and spread to a great distance, just as I have described and figured it for several fungi in my cited book. *The smut on the barley in Yokohama is therefore a fungus distinct from our dusty smut.* Unfortunately it was spring, and I had for comparison no smutty barley grown in our own fields. But in the following summer, as soon as the smut showed itself in the barley fields, I made cultures from its spores and found that they germinated just like those from Japan. I repeated the experiment with barley smut taken from as many places as possible in the vicinity of Münster in Wesen, but the spores always germinated without conidia. I communicated this observation to my distinguished friend and patron, Prof. Julius Kühn, of Halle, and requested from him some spikes of wheat containing fresh smut. In these also was the same fungus as in the barley, the spores produced no conidia. *According to this the smut fungus on barley and wheat is not the same as that on oats.* In spite of the similar spore form a great difference between the two is shown in the germination of the spores in nutrient solutions.

The negative results of barley infections, and the endeavor to give a natural explanation, led to a further positive result, the discovery of a new form of smut, which, in spite of its universal distribution, had remained unknown, and for the recognition of which it was first necessary to find out, by means of the artificial culture of smut fungi, a new method of diagnosis. I call the new fungus, which occurs on the Hordeæ, *Ustilago hordei.* The consonant behavior of the fungus from Japan and from Germany is evidence at once of its specific peculiarity and its value as a member of the genus *Ustilago.**

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*A varying behavior during spore germination in water, sometimes with and again without conidia, was known long ago for the dusty smut, but owing to the rudimentary germination of the spores in water was not followed further. Moreover, seven years

B. For the infection experiments with millet smut, *Ustilago cruenta*, I selected the largest kind of millet, viz, *Sorghum saccharatum* (*nigrum*), because in the others the seedlings are entirely too small and therefore not suited for the experiments. Even the seedlings of the sugar millet are quite small in comparison with those of our own cereals. They have, on the other hand, the advantage that at first they grow much more slowly than the seedlings of oats and barley.

The millet smut (*Hirsebrand*), like the dusty smut, appears in the fruiting spikelets, and the grains are changed into a black mass of smut.* The spores germinate readily and produce sprout conidia in endless abundance. These are deposited in the nutrient solution as a precipitate, which differs strikingly from that of the dusty smut in its whiter color and the non-gelatinizing membrane of the conidia.

I. The first series of experiments, in 1885, was reduced to 32 plants by a hail storm. The germinating embryos were infected with the sprout conidia of *U. cruenta* by means of the atomizer. Among the 32 plants which remained there were, in autumn, 12 smutty and 20 sound.

II. The next series of experiments was made in the following year by direct infection of seedlings, which, however, were not all of the same size or in quite the same stage of germination. In autumn the harvest of 270 plants yielded 120 sound and 150 smutty.

Early experiments, with sufficient materials, where the seedlings were rigorously sorted according to their size, were not begun till 1887.

III. First, the smallest plants, in which the growing point was just emerging from the grain, were picked out and infected. Here, in autumn, out of 250 plants were harvested 180 smutty and 70 sound.†

IV. Next, seedlings were selected with shoots a centimetre long. Here, in autumn, from 150 infected plants were gathered only 24 smutty and 126 sound.

V. Seedlings with shoots 1½ centimetres long. Here, in autumn, from 190 infected plants, 12 diseased panicles were counted; 178 remained sound.

VI. Seedlings with shoots 2 centimetres long and projecting from the sheath. In autumn, out of 220 plants only 4 were diseased, the rest were sound.

VII. Seedlings with shoots which had grown through the sheath to a distance of 1 centimetre. Here, in autumn, *no smutty plants* appeared.

VIII. As soon as the millet seedlings were large enough to be infected by spraying the germs into the heart from above, 192 plants,

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ago, in my first culture experiments with the dusty smut, I discovered that the smut spores from barley would not germinate even after one year, while those from oats still germinated readily after more than six years.

* In more than three hundred smutted millet plants, for which I have to thank Prof. Julius Kühn, I found the smut nowhere except in the ovaries.

† There can be no doubt that the larger per cent of smutty plants in the millet as compared with oats, is referable to the slower growth of the millet seedlings. Otherwise, on account of their smallness, the seedlings are less favorable objects for infection than those of oats.

which had reached a size of about 5 to 6 inches, were thus infected. Where the germs touched, a local sickening was visible after 4 to 6 days. This took the form of a yellowing and subsequent shriveling of the leaves. These were covered with penetration spots, and penetrated in all parts by richly branched fungous threads. The leaves died, but neither completely nor with the formation of smut in their interior. As soon as the plants were compensated by new sound leaves from the bud, they appeared healthy again; but were, of course, somewhat delayed in their development in proportion to the disturbance. Moreover, this whole series of plants proved sound, and brought forth healthy panicles.

IX. An additional 210 millet plants, about a a foot high, were infected in the heart from above. Here the effect was still more remarkable. The young leaves which had been touched and attacked, shriveled considerably after a week, the heart of the plant became very pale, and the mycelium grew luxuriantly through all the attacked leaves. Nevertheless, even here, the diseased leaves were subsequently replaced by sound ones, and aside from the delay in development the plants suffered no injury. The subsequent harvest yielded only sound panicles.

X. Again, 120 plants, 1½ to 2 feet high, were infected in the same way. The symptoms on the attacked leaves grew worse in proportion to the increased size of the vegetative point, so that from external appearances it seemed as if the plants would perish; but this did not happen, and again the new leaves were sound. The result in autumn was the same as before, only sound plants.

The panicle can not be reached by infection from above in millet any more than in oats. It is securely inclosed by the leaves of the bud, and subsequently pushes out sidewise from these. For this reason, additional infections, when the plants were 3 to 4 feet high, had a purely negative result. The young leaves were luxuriantly traversed by the penetrated germs, but the panicles remained uninjured.

The final result of the experiments with millet smut on the sugar millet [sorghum] points to the following conclusions: The plants can be infected with the smut germs in all young undeveloped parts; but only those smut germs which have penetrated into the *nascent* shoot, and have thus reached the growing point, actually produce smut in the panicles, which is its exclusive location. These fungous germs, which have penetrated the host plant in the first stage of germination, remain, as in oats, latent in the plants till their sexual maturity, and then only do they come to maturity in the young ovaries, and to the production of smut beds, which is equivalent to the destruction of the ovaries or of the panicle.

It is worthy of remark that we can not discover the least sign of disease in the plants which bear the destructive germ concealed in their growing points; that, on the contrary, they appear even more luxuriant than the others; and furthermore, that the smutty panicles appear much sooner than the sound ones. For example, in the third series of experiments. 102 smutty panicles had developed up to September 3,

but yet no sound ones. I fully believed that all of the plants would be smutty, until on September 10, the first sound panicle appeared. On October 1 were counted 30 sound panicles and 140 smutty ones; and finally, on October 15, the proportion was 180 diseased, smutty plants to 70 sound ones. In plants which conceal the germ of destruction we find slight traces of the fungous threads only in the nodes and in the growing points, and in the latter they do not attain further development until the ovaries are formed. They then proceed to the formation of spores in this place only, not in the leaves, where they remain sterile and do not produce a single smut spore. The ovaries swell mightily with the rapid and abundant development of the fungus in them, and finally, like the horns of ergot, grow to be many times their natural size, projecting far out of the panicles. Finally, after the complete spore formation of the fungus, they break up and allow the spores to dust away. In this stage scarcely a trace of the mycelium of the fungus is to be found in the host plant.

The behavior of corn smut is directly opposed to that of the smut forms which inhabit the grain exclusively. This form can produce its smut beds on any part of the host plant, and in the strange and repulsive similitude of cancriform swellings and ulcers.

For infection experiments with smut germs the big corn plant is an ideal object. All parts of the maize, from the seedling to the inflorescences and fruit-spikes, are developed on a large scale, and are easily accessible for each form of the experiment. The corn smut itself, *Ustilago maydis*, is also a smut form especially suitable for the infection.

C. I began infection experiments with corn smut in the spring of 1885. The spores of *Ustilago maydis* do not germinate in water, or do so very sparsely only after some years. In nutrient solutions they germinate without exception and immediately. They are therefore consigned to nutrient solutions or nutrient substrata, and not to mere water, for full germination. They produce an endless quantity of sprout conidia, and still more rapidly than the two forms of Ustilago previously mentioned, *U. carbo* and *U. cruenta*. The conidia are thrown down as a white, granulous precipitate, which appears even whiter than the sediment of *Ustilago cruenta*. But in this case the sprouting of the conidia takes place *upon* the nutrient solution, where mold-like pellicles are formed, from which the conidia can easily dust off through the air.*

I. In the first series of experiments, in 1885, I infected only young seedlings in different stages of germination. In more than ten distinct sets of experiments the seedlings were copiously sprayed with conidia and were afterwards set out in the field.

After 16 days, very scattering signs of smut were visible among the plants which had been infected in the earliest stage of germination. Below, upon the axes, a smut swelling was developed, in consequence

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* This formation of sprout conidia in the air is likewise peculiar to a number of other *Ustilagineæ e. g.*, *Ustilago bromivora* and *Ustilago destruens*, also *Tolyposporium junci*, etc.

of which the plants died. The loss, however, was trifling, amounting to only 4 or 5 per cent. The seedlings which were infected in later stages gave only 1 or 2 per cent of loss. The last set, with open sheath, remained sound.

The few plants which became diseased so early, and which died completely, suggested in their appearance the smutted maize seedlings which Kühn observed and described. The time of the appearance of the smut swellings after the infection also agreed with Kühn's statement.

I now waited, expecting that, as had happened with oat and millet smut, the corn smut would appear upon the fully developed plant, especially in the fertile spikes, but I waited in vain. Already, the fact that, from this time on, the strongly developing axes remained entirely sound had made me suspicious, and when autumn came, and the ears were formed, *not one out of many hundred plants was smutty.*

Before the issue of this experiment, which had consumed several months, I stood at first helpless. The infections were made as carefully as possible, and the failure was not to be explained by these. This must have other causes. All reflections in the course of the winter led me back to this conclusion, *that probably in maize the infection of young seedlings could not lead to the production of smut in the full-grown plant*, as is the case in smut forms living in the grain. At the time of this first series of experiments, in the year 1885, I still held to the old view, universally current until now, that smut germs generally could penetrate only into the young seedlings in order to appear later as smut beds in the full-grown plant, and that, consequently, a penetration of the germ into the plant when it had passed the seedling stage was not possible. I had not then tried infections in the heart of full-grown plants. In the failure of the infections with the corn seedlings I first found the suggestion for the latter. Gradually I came to the conviction that the view that the fungous germ could penetrate only into the seedling was an embarrassing one; that the seedling consisted only of the young parts of plants, and that, of course, the penetration must occur not exclusively in the seedling but also in all places which were in a young condition similar to the seedling. This applied, first of all, to the growing points, the buds, the heart of the plant which was still growing and forming new tissues overhead. Here, therefore, the infections must be made. These I now prepared for by sowing kernels of corn in long beds, in the open air, at the end of April of the following year (1886).

II. In the first half of June, 1886, the maize plants of a long bed were abundantly infected in the heart by means of a suitable spraying flask. For the most part these plants were about a foot high, and the young leaves of the growing point had formed cornets very suitable for receiving the infection. The plants remained uncovered, as a period of dry weather had set in. The injected fluid containing the sprout germs, which at first covered the growing point, was not to be seen on the following days. The leaves of the tip continued to develop during the

next 10 days normally and luxuriantly. On the twelfth there appeared an etiolation in the heart of the plant, which extended upward as far a the leaves had previously been touched by the injected fluid. In the blanching leaves, the surface of which was strewn with penetration spots, there was an abundant production of mycelium, which had penetrated in all directions. In addition, the commencing hypertrophy of tissue was already clearly visible in the attacked and ever-paler appearing parts. After an additional week, in which the growth of the whole plant, including the parts attacked, had proceeded considerably, the cancroid swellings of the smut pustules reached full development and a size never before seen. The entire leaves were covered with a complete crust of pustule, which in part made them almost unrecognizable; out of all parts of the axis, in fantastic forms like ulcers, the great smut swellings grew luxuriantly, so that the plants in their entirety were deformed and spoiled—a complete picture of disease. Scarcely had the rapidly developed swellings reached full size when they lost their white appearance through internal change of color. The spore formation quickly included the whole densely interwoven mycelial skein inside of the swelling, and the final result was a black mass of smut spores inclosed by the external tissue layers of the host plant, *e. g.*, of the pustule.*

Of all the plants which were infected, *i. e.*, more than a hundred, none remained sound after 4 weeks. The smaller they were at the time of infection, the more they suffered. The extension of the young axis, which was disturbed by the formation of smut and the accompanying hypertrophy of tissue, was afterward completed. Whole plants were wasted and distorted by the fungus into miserable objects. They lay in part upon the earth and perished without exception. On the larger plants the formation of pustules was localized upon the upper parts, the only ones attacked. The lower sound leaves continued to nourish the plants and they did not die. In only twelve of these plants did the injected fluid reach as far as, or penetrate into, the nascent staminate inflorescence. To the extent that this happened the parts soon became smutty, sometimes the tips only, and again the lower portions. The glumes and the filaments swelled more than fifty-fold, and in isolated cases became tumors which, by their weight, afterwards bent down the whole panicle. The long series of charts which I have hung up, and which were drawn by my young friend and associate, Dr. Istvanffi, of Klausenburg, will serve to illustrate the most striking cases from these series of experiments.† In the upper part of one of the pictures, in the

* Through this pathological picture of the cancerous tumors on the maize plant we arrive involuntarily at the notion of what the symptoms would be if the smut spores were not black, and were not produced in such masses as happen in the maize, and if the substratum were not a vegetable, but an animal organism.

† These charts, and many others illustrating the life history of smuts, may be found in Dr. Brefeld's *Heften* V and X, to which he desires me to call attention. These are published by Arthur Felix, Leipsic, Germany. Part X, giving *in extenso* the results here summarized, is now passing through the press.—Tr.

attacked staminate inflorescence, there are a number of fertile blossoms the individual ovaries of which reached the size of a walnut, and were still crowned with the base of the style.

On such plants as survived, the appearances of disease diminished after 6 weeks, with the ripening of spores in the pustules, and not long after only the dried pustules remained; aside from these, and the persistent distortions of the upper part of the axis, nothing more was to be seen of the smut. During this time the fertile inflorescences appeared below on the axis, in the axils of the leaves which had remained sound. No smut was to be seen on these, and later they were pollenized from the staminate inflorescences which had remained sound and developed normally. In autumn, a large number of ears bearing sound, ripe kernels were harvested from these plants.

After this conclusion of the series of experiments no doubt could remain that the smut germs develop, and within 14 days, too, in the particular spots of the young parts of the plants into which they have penetrated, and in these only. All parts of the plants which are not touched directly by the germs remain sound, so that sound ears can be gathered in autumn from maize plants which are infected in the heart in summer and which become smutty on all parts that have been touched directly.

But here was still necessary the additional experiment of verification by which it must actually be proved that the fertile inflorescences also become smutty as soon as they come into direct contact with smut germs while still in a very young condition.

III. Again, the next year I had whole beds of maize plants prepared in the field for supplemental infections. I waited for the time when the pistillate inflorescences should begin to appear on the sound plants. These showed distinctly at the end of July, on the third to fifth internodes of the axis, by a swelling of the leaf sheath. As soon as the swelling had reached the point where the otherwise firmly encompassing ligule was pushed up somewhat from the axis, the infection was made by spraying into the leaf sheath so that the injected fluid containing the sprout germs stood even with the rim of the ligule. More than one hundred plants, each of which, as a rule, afterward brought forth two ears, were infected in this way.

The results of the infection were visible at the expiration of 14 days. The leaf sheaths were burst open, and the ears within came to view as a continuous smut pustule. Individual ears swelled to the size of a child's head, and only here and there distinguishable were the peculiarities of the fertile inflorescence, the ovaries of the young ear; otherwise, for the most part, was to be seen a single deformed, repulsive structure. No fertile inflorescence, which was infected when a young bud, remained uninjured. The narrowly local action of the infection could be shown directly on the plants on which the lowest flower buds were infected but not the upper. The latter always remained sound; the former alone were destroyed.

IV. The formation of the pustules in the very young ear did not yet exactly correspond to the appearances which I had formerly seen on fertile spikes, where each ovary had swollen individually into a tumor as big as a nut, so I extended the experiments still further. Ears which already bore silks were somewhat opened at the tip, and only the exposed ovaries of the spike were infected by means of the sprayer, while the lower were not infected. If the presumption as to the narrowly local action of the infection were correct, then in this case also only the upper ovaries would become smutty.

The ovaries behaved with military punctuality. After 16 days the upper ones swelled, and became almost egg-sized smut tumors, as the suspended pictures show. All of the ovaries lower down on the same spike yielded sound, normal grains.

V. There remained only the incipient adventive roots on the lower nodes of the axis as susceptible objects of attack. The beginnings first appear when the growing points and the leaves have reached full size, *i. e.*, when the plants begin to elongate. They appear in a ring around the nodes near the ground; the farther up they are the shorter they remain, and then, generally, they do not penetrate into the earth.

As soon as the tips of the roots were exposed, the infections were made by spraying with the atomizer, and then a shelter from rain was placed over the roots. Once more, after 3 weeks, individual root tips showed swellings of the bigness of a nut on their ends, which meanwhile had elongated. These swellings developed into normal smut pustules, as shown in this sketch.

VI. To round out the experiments, the silks which hung far out of the fertile inflorescences were also infected by spraying. Here the infection had no result, as was to be expected. The silks remained unchanged, and their spikes, which were protected from the infection, also remained entirely sound. The silks, indeed, are no longer young tissue. The fungous germs still penetrate occasionally, but do not develop, because the luxuriant growth of tissues necessary for the formation of pustules is excluded.

VII. All infection experiments made by spraying into the heart of the plant when the sterile inflorescences were already visible in the growing points, were also without results. Penetration spots were still to be found, and also fungous threads in the superficial tissues. Externally on the leaves a slight shrinking was also observed on isolated spots, but they recovered because the fungous germs found in the already too old tissues no suitable place for the production of smut beds. I have already referred to the fact that penetration itself is impossible in still older parts of the maize plant which have reached nearly full growth.

According to this, the final result of all the infections with corn smut on maize is entirely different from the previously described results with smut fungi living exclusively in the grains. The smut germs come to

full development and produce smut pustules and spore beds on every spot of the still undeveloped parts of the plant into which they have penetrated. The action of the germ is narrowly localized—only those parts of the young plant become smutty which have been attacked directly by the fungous germs; all the rest remain normal and sound. The formation of the smut pustules begins quickly, at longest, 3 weeks after the infection.

The complete result of all the here-cited infection experiments with dusty smut, millet smut, and corn smut affords, in the first place, indisputable proof that the germs of smut fungi which live saprophytically outside of the host plants can produce smut diseases.

When the smut was nourished saprophytically longer than a year in continual reproduction outside of the host plant, then only did the outgrowth of the conidia into germ tubes cease. Along with this the power of infection was extinguished, *i. e.*, with the disappearance of a comprehensible morphological character, for the germs can only penetrate into the host plants by means of their germ tubes.

The earlier view that only young seedlings of the host plants are receptive to the fungous germ has not been sustained. On the contrary, the fungous germs can penetrate into all sufficiently young parts of the host plant.

In the grain-infesting smut fungi, *e. g.*, in the dusty smut and millet smut, of all the fungous germs which have penetrated into the young parts of the plant, of course, only those come to maturity, *i. e.*, to the production of smut diseases, which reach the growing point and the place of the here-included nascent inflorescence. This takes place only in the germs which have penetrated into the young seedling in the vicinity of the root nodes during the first stage of germination. For all the other germs which have penetrated later this is already impossible. The vegetative tips with their incipient blossoms, the later place of development of the smut, have already grown away from these, and consequently are entirely out of reach inside of the plant.

The relative rapidity of germination in plants receptive to smut diseases aids materially in determining the subsequent appearance of the smut, *i. e.*, the development of the germ which has penetrated. This may vary according to the accidental temperature prevailing at the time of germination, therefore according to external influences; but from internal causes it will also be dissimilar in particular individuals, which accordingly may show an individually different receptivity.

In the peculiarities formerly stated, and now clearly established by me, the natural explanation is given, so far as regards smut diseases, to the terms "periodic receptivity," "subsequent immunity," and "individual predisposition to an infective disease."

Especially noteworthy is the long incubation period from the penetration of the fungous germ to the outbreak of the disease. The germ of the destructive disease is taken up in the earliest youth of the plant

and first comes to destructive action when the latter is sexually mature. Here we have a case of "definite periodicity in an infectious disease" explained clearly and naturally by actual peculiarities. The disease germs remain latent, and traces even are scarcely to be found. The attacked individuals are even stimulated in their growth, and are in advance of the sound ones—until suddenly at the time of sexual maturity the disease germs, hitherto concealed within, come into destructive operation.

In smut fungi, which do not live exclusively in the grains, but also appear and form smut beds in other parts of the plants, *e. g.*, in corn smut, the infection remains local. The fungous germs proceed to the development of smut in the sufficiently young parts of the plants only on those spots into which they have penetrated. The plants are receptive to the infection as long as young parts are being produced on them. Only when this is no longer the case, *i. e.*, when the plants are full grown, does the stage of immunity begin. To what extent the peculiarities in the smut fungi and smut diseases, which are now explained, may be of value for judgment upon similar occurrences in infectious diseases, especially in pathology, is self-evident.

In conclusion, I may be permitted to observe that seven years' labor was necessary to reach the conclusions on smut fungi and smut diseases given in my first address four years ago, and in this present one. The substance of this address is here made public for the first time as original work.

RIPE ROT OF GRAPES AND APPLES.*

By E. A. Southworth.

Plate XVI.

HISTORY OF THE FUNGUS.

Judging from the bibliography of the fungus of ripe rot and from the very scant specimens in the herbarium, it seems to have received four or five distinct names at the hands of three or more investigators. The fact that it varies greatly in its microscopic and external characters probably accounts for the vicissitudes of nomenclature through which it has passed, and for the fact that one authority has given it two and perhaps three names.

In 1854, M. J. Berkeley described and figured in the Gardeners' Chronicle a disease of the grape caused by a fungus to which he gave the name *Septoria rufo-maculans*. He describes the fungus as attacking ripe fruit and causing considerable destruction. From his figures and general description there is little doubt that the fungus is the same as

* *Glœosporium fructigenum*, Berk.

the one which is the subject of this paper. Later he changed the name to *Ascochyta rufo-maculans*, and it is described under the latter name in Saccardo's *Sylloge*, although Von Thümen in Fungi Pomicoli calls it *Glœosporium rufo-maculans*.

In 1856, in the same journal, Berkeley described and figured a fungus on apples under the name of *Glœosporium fructigenum*, and said:

It was impossible not to call to mind the little fungus figured upon grapes, * * * and the subjoined figure compared with the one there given would at first seem to indicate an identity. But the spores were more inclined to be curved, rather longer, and not so variable in size, and the want of a perithecium separated the two widely from each other. * * * I would not affirm that the two productions are essentially different, and the more especially because in external appearance and habit they are so perfectly identical.

In the Gardeners' Chronicle for 1859 Mr. Berkeley describes a fungus on peaches and nectarines, *Glœosporium læticolor*, as new to science. The description is not accompanied by figures, and it varies in some important points from that of the two preceding fungi, but in closing Mr. Berkeley says:

A plant of the same genus destructive to apples is figured and described in this journal. We may also refer to the very similar production on grapes.

As we possess no specimens of *G. læticolor* it is impossible to draw any conclusion as to whether this is or is not the same as *G. fructigenum*, but it does not seem impossible. The chief points of variation may be accounted for by the change of host.*

Still another fungus, or the same fungus under another name, was described by Berkeley and Curtis from South Carolina in Grevillea, in 1874, as attacking apples. They give it the name *Glœosporium versicolor*, and remark that "it is very different in habit from *G. fructigenum*, which also occurs on apples."

It is to be noted, however, that the specimen from which Berkeley described *G. fructigenum* was kept in the house, and if this was not the case with the fruit from which the other fungus was described there is a wide chance for variation, especially in a fungus which varies greatly even under the same conditions.

The herbarium of the Department gives very little aid in reaching any decision as to the identity of these fungi. There is one specimen labeled *G. fructigenum*, from Newfield, New Jersey, on rotting pears, but I am not sure as to the authority for its identification; and another of *G. versicolor*, from Delaware, which was distributed in Ellis and Everhart's North American Fungi, No. 1897, on apples. From a comparison of the two specimens there seems to be no doubt that they represent the same fungus. Of course it is impossible to form a decision which would be of any value from these premises, but it is evident that the

* W. G. Smith has recently figured a fungus on grapes which he calls *G. læticolor*, and which from the figures seems to be the same as the *G. fructigenum* of this article.

descriptions given, if they do represent different fungi, are not sufficiently accurate to give us any criterion of identification.

In the Annual Report for 1888 Mr. Galloway described a fungus causing the bitter rot of apples, which he identified as Berkeley's fungus *Glœosporium fructigenum*, and which agreed closely with the herbarium specimens.

In the summer of 1888 Prof. F. L. Scribner found what he supposed to be a new fungus on the grape in the Department grounds. He examined it, but as its similarity to bitter rot of grapes threw some doubt on its specific value no further observations in regard to it were made. In the following season it was found again by the writer, and since then it has come to the Department from several sources.

A study of its structure at once suggested a close relationship with the fungus causing bitter rot of apples, and also with the one causing the bitter rot of grapes. It differs from the latter, however, in several points.

Owing to its similarity of form with bitter rot of the apple, a series of experiments was undertaken to ascertain whether or not the two were identical. Living spores of the grape fungus were inserted under the skin of healthy apples by means of a flamed knife, and other apples similarly punctured but not having the spores inserted were used as checks. At least twelve apples were thus infected, each apple being infected at three points. In every case but one the fungus developed, and with but one exception at all of the infected points. The one exception was where spores were used which a few days later were found to be incapable of germination. In case of another apple, spores were purposely used which were supposed to be past the power of germination. The result was that the fungus developed at one point of infection only, and this was probably the result of carelessness, as the knife was not flamed after being used to infect an apple with spores from another grape, and the spot into which the knife was first pushed received some of these spores that were capable of germination. None of the checks developed the fungus. The rot spots began to appear in about 3 days, and pustules made their appearance in from 5 to 8 days.

Apples attacked by the typical bitter rot fungus were obtained from Arkansas, and the spores were used for infecting grapes in a manner similar to that described for apples.

The results were not so striking as in the former case, but in a small proportion of the infected grapes typical pustules with spores were developed, and this was not true of the checks. Many of the infected grapes, which did not show pustules, decayed in a manner typical of grapes attacked by the fungus, but grapes were so much harder than apples to preserve from the attacks of saprophytic fungi that in most cases they succumbed to these before the *Glœosporium* had a chance to complete its development. The most successful infection experiments

were made on Malaga grapes, three or four berries out of a dozen developing the fungus, but grapes grown on the grounds were also successfully infected.

The pustules produced by inoculation were exactly like those produced in a state of nature, and the fungus in apples infected with spores from another apple was exactly the same, both as to structure and effects produced, as in apples infected with spores taken from the grape.

These experiments leave no doubt that the fungus found here on the grape is the same as the bitter rot of apples. And from a comparison of Berkeley's figures and description there is very little doubt that it is identical with his *Ascochyta* (*Septoria*) *rufo-maculans.* The strict law of priority might demand that we now make the specific name *rufo-maculans*, but since the better known *G. fructigenum* is also Berkeley's name it will remain so in this paper. It is perhaps well to say that Professor Cavara has kindly compared this fungus with the *Tubercularia acinorum* described by himself and states that the two are distinct.

The proper settlement of the whole question depends upon the comparison of type specimens not accessible to us, and it is hoped in what follows to give a sufficiently full description of the fungus so that others who have these specimens within reach may be able, by comparing them with the figures and descriptions, to decide whether they represent distinct species or not.

The popular name which should be given to the disease on both grapes and apples is nearly as much of a question as that of the scientific name of the fungus. The old term, bitter-rot, so applicable to the disease of the apple, will not do for the grape, as the fungus does not give the latter fruit any bitter taste, and the name is already given to another grape-rot, caused by a fungus, which does impart a decided bitterness to the ripe berry. The term anthracnose is also preëmpted, otherwise that might be used, as this fungus belongs to the same type as others causing this disease. The name ripe rot, which has been finally adopted, may answer the purpose in spite of its lack of euphony, as the fungus attacks neither grapes nor apples until they begin to ripen.

EXTERNAL CHARACTERS.*

On the apple.—The presence of the fungus is first indicated by one or more brown spots somewhere on the surface of the apple. These may not be more than a quarter of an inch across at first, but they spread very rapidly and in time cover the whole apple. The spots have the appearance of ordinary decay except that they are a little sunken, and are apt to be somewhat firmer than is natural where this fungus is not present. Moreover, after the spot has existed a few days, small black pustules make their appearance on the surface. These are often so numerous in the center as to give it a black color, and those nearer

* Colored drawings of the external effects of this fungus will appear in the Annual Report for 1890.

the circumference are likely to be arranged in circles. It not infrequently happens that the pustules are not black at first, especially when the apples have been kept in a moist environment. They may appear quite white before they break through the cuticle, and later the spore masses give them a pink color over the top. Sections through diseased apples show that the tissues are decaying for some distance; and in preparing a partly decayed fruit for eating, great care must be taken to remove every fragment of this discolored tissue, as a scarcely perceptible amount can impart an intensely bitter taste.

On the grape.—The fungus seems to attack only ripe grapes, and when the diseased grape is a purple one no change of color occurs, but the berry decays and the skin seems to be raised up in pustules over the diseased portions. On white grapes the fungus produces a very characteristic appearance. A small, reddish-brown spot appears on the side of the berry; this spreads and becomes darker in the center, so that by the time it has spread over half the berry it has a purplish center merging into a narrow bright-brown border. It is moreover covered with minute pustules which are at first whitish, then exude a flesh-colored powder, and finally become dark brown or even black with age. The berry finally becomes quite dry and shriveled, but even in this condition it does not become black like those attacked by black rot, but may even preserve a translucent appearance. On a few grapes, whose tissues were at the same time hardened by the presence of the mycelium of *Peronospora viticola*, the areas attacked by the *Glœosporium* had sunken in, as is the case with the apple. On the grape the pustules often continue bearing spores, and hence retain their flesh-colored appearance even when the berry is nearly all dried up. The fungus does not communicate a bitter taste to this fruit.

MICROSCOPIC CHARACTERS.

The structure of the fungus is so variable that it is almost impossible to frame a description that will be true under all circumstances.

The appearance of the fruiting bodies differs on nearly every berry that the fungus attacks, although it is a somewhat curious fact that the pustules on any one berry are very nearly alike. The color and shape of the spores are the most constant characters, but the latter varies considerably. In the following description the most characteristic and common variations will be noted, but they by no means comprise all that may be expected even in a short study of the fungus.

The first stage in the formation of the fruiting body is the most constant one. A cushion of stroma forms just below the upper wall in a group of the epidermal cells; as it increases in size the contents and lower wall are pushed downwards, the cross walls are broken or absorbed, and the upper wall pushed upward until it is ruptured and the fungus exposed to the air. As soon as the stroma has attained about 20μ in thickness it can be seen to consist of parallel threads arranged at right angles to

the plane of the epidermis, and containing frequent septa. The stroma mass is colorless at first and shaped like a double convex lens. The hyphæ composing it are adherent along their whole course and may branch. The central portion is often composed of larger, more transparent hyphæ. When the cuticle is finally ruptured the shape of the stroma may change considerably, from the fact that it meets no further resistance to its upward growth. It is also from this time on that the changes which cause the fungus to be so variable take place. Sometimes the free ends of the hyphæ bear spores over the entire surface so that the stroma forms a compound sporophore, but usually the large cells comprising the center of the stroma mass break down, and the entire center becomes separated from the outer portions and may pass out through the opening in the cuticle. In this case spores are borne around the circumference of the stroma and the cavity left in the center develops basidia and spores on its sides, thus producing a pseudo-pcynidium. The amount of the stroma that disappears after the cuticle is ruptured varies exceedingly. In some cases the original mass seems to remain and grow dark colored. In other cases a large amount of stroma still remains, but it becomes dark colored, and enough of the original mass has disappeared so that the spores are borne on a very concave surface. The stroma grows dark colored as soon as the cuticle is ruptured, but the lower part of the central portion usually remains colorless except in very old pustules. In some of these, especially on the apple, it looks as if the stroma had greatly increased in quantity and in a measure at least lost its spore-bearing property. Whether this apparent increase is due to a growth from the base of the stroma has not been directly observed, but from the appearance of the sections this conclusion is almost irresistible, and the fact that the base often remains colorless below the center supports such a view. Examples of this are frequent on the grape, but on the apple the older dark-colored pustules are especially large and after a time seem to stop forming spores. When kept for a long time in a moist environment the ends of the hyphæ sometimes grow out into long dark-colored filaments.

Besides these more common forms there are cases where the stroma almost completely disappears after the cuticle is ruptured, and the result is a typical Glœsosporium form, viz, rather long basidia borne on a thin stroma and bearing oblong spores at their free ends. Still another case was found where, instead of a true stroma, the hyphæ were independent down to the very thin, irregular layer of pseudo-parenchyma always at the base of the parallel threads; thus forming extraordinarily long basidia with spores at their ends.

Spores.—The spores are unicellular but may become two or even three celled at the time of germination. They are colorless singly but flesh colored in mass, irregularly oblong, sometimes curved and often pointed at one end, or even ovate. They vary greatly in size as well as in shape, and in the case illustrated in Fig. 4 are much longer than

usual. They are apt to be shorter and thicker on the apple, and in dry than in moist surroundings.

Mycelium.—The mycelium is septate and branching, usually colorless, but may become darker colored with age. It is both intra and inter cellular, preferably the latter. In the apple it is sometimes so thick just below the epidermis that it nearly forms a continuous sheet, the threads lying parallel side by side.

The spores begin to germinate in water in about six hours. They swell considerably. The vacuole disappears, but the spore contents pass into the germ tube and the spore is either left partially empty or filled with very thin, slightly refringent protoplasm.

In several germination experiments secondary spores were produced in large numbers. What the conditions were that decided their appearance could not be determined. They were produced both in nutritive media and water, but seemed to be especially numerous where the ends of the hyphæ came in contact with some hard substance like the cover glass, and in two cases the addition of an extra drop of nutritive medium had the effect of stopping their formation. They may be formed on the end of the germ tube when it is no longer than the spore itself, and as the mycelium becomes better developed nearly every branch may produce a secondary spore on its end. They are developed as simple, colorless expansions of the end of the tube, which soon becomes delimited from the rest of the hypha by a septum. The walls become thickened and dark colored, the contents nearly transparent, and a bright spot, strongly refracting, like an oil globule, makes its appearance in the center. The mature spore has a very faint olive tinge and is nearly ovate in outline, being truncate at the smaller end on account of the septum which cuts it off from the hypha. They only retain their original regular form for a short time, the walls soon pushing out in all directions, thus forming a very irregularly lobed body. Sometimes these secondary spores send out a germ tube, and when this happens the bright spot disappears and the spore becomes lighter colored, the contents having apparently been exhausted. More often, however, the mycelium branches just below the point of insertion of the secondary spore, and even in this case the latter sometimes undergoes the changes just described.

The contents of the growing mycelium are at first granular, later becoming more homogenous, and by the time they have reached the stage illustrated in Fig. 7*b* occasional vacuoles make their appearance. Septa are formed soon after germination.

Setæ.—In a few cases brown setæ have been found in the pustules, both on the apple and on the grape, but mostly on the latter. They do not seem to be sufficiently constant or numerous to characterize the species. Where found they are two or more in a pustule, are septate, and of varying length.

Except for the shape and color of the spores this fungus would seem from the description to be identical with that of bitter rot of grapes

(*Melanconium fuliginea*, (S. & V.) Cav.) but there are several points of difference. The spores of bitter rot are navicular and fuliginous, and the stroma is made up of smaller and more uniformly dark-colored cells; moreover it does not seem to be as variable as that of the ripe rot, but there is a more regular disappearance of the upper central portion of the stroma, leaving a cavity the sides of which are always lined with spores and basidia. The formation of secondary spores has never been observed for the Melanconium and the mycelium proceeding from the spore is very different from that of the Glœosporium and is fuliginous. It does seem, however, as if the two fungi ought to be placed in the same genus, but it is not the purpose of this paper to make any changes in nomenclature.

Later stages.—In the Annual Report for 1887 Mr. Galloway described a stage which seemed to be an immature pycnidium. In hopes of obtaining more definite results in this direction, a number of apples which showed numerous characteristic pustules were placed under bell jars in the fall and left until midwinter. When examined, the stages figured in the annual report were found; but in some cases the fruiting body was composed of one outer layer of dark-colored cells, those inside being colorless, and the contents of the central ones broken up into small particles. The structure of the entire body closely resembled that of the immature pycnidia of black rot of grapes, the colorless cells being isodiametric and nearly hexagonal. No spores could be seen, but in one or two cases the contents of the conceptacle were not fully distinguishable, and seemed to be partly composed of radiating lines passing from the circumference to the center. From the top of these bodies arose the characteristic stroma mass, or rather, in this case, a compound sporophore, bearing spores at the free ends of the hyphæ. Still later, one conceptacle showed two asci containing partly developed spores. Unfortunately, the apples were so overgrown with Penicillium and so putrid from the attacks of insect larvæ and bacteria that they had to be thrown away before any more definite results could be obtained.

ECONOMIC NOTES.

The fungus has been known on the apple for a long time, Berkeley's first description of it dating back to 1856. During the past five years it has proved very destructive in certain localities especially in the South and Southwest. One fruit grower from Arkansas reported that from the effects of the rot in the summer of 1887 his orchard of seventy-five trees would not yield 25 bushels. Until the present season only solitary cases have been known of the fungus attacking the grapes, but during the past summer we have received specimens from Connecticut and New York. In the latter State it was observed in Wayne, Cayuga, and Seneca Counties and was found on grapes sent in from the grape-growing district in the southeastern part of the State. It seems to be slowly spreading on the grape, and attacks the fruit often after it is

stored in crates preparatory to sorting. It seems to spread in these large crates, and was found in the most active stage as forming a large per cent of the cullings from the packers.*

Thus far it has been by no means a serious enemy to the grape, but the chief danger for the future seems to lie in the fact that it has proved so formidable on the apple and that the grape can not be considered as safe from its attacks if apples in the vicinity are diseased.

It attacks neither fruit until the ripening process has begun, and with the apple as with the grape may develop and spread after they are packed and stored.

Treatment.—From the foregoing it is evident that it is of great importance to carefully cull all fruit among which the presence of the disease is suspected, as a diseased fruit may infect the healthy ones that lie in contact with it. It has been shown, however, by one experiment, that this disease can be almost wholly avoided by the use of fungicides.

In the summer of 1888 the Department commissioned Mr. Geo. Curtiss, of Stafford County, Virginia, to make a trial of certain fungicides in the prevention of the disease. Mr. Curtiss had repeatedly lost all of certain varieties by this fungus, and his orchard offered a good field for experiment. In order to make the value of the remedies used perfectly clear he left some of the trees unsprayed, and in one case he sprayed only half of a tree, leaving the other half unsprayed as a check. The remedies used were potassium sulphide (one-half ounce to a gallon of water) and the ammoniacal copper carbonate. The sprayings were not begun until August 18 for the potassium sulphide, and August 27 for the copper carbonate, too late in both cases for the best results, as the disease had already made considerable progress. But even under these unfavorable conditions the result was very marked. The apples that were not diseased at the time of spraying were perfectly protected, while the unsprayed trees dropped all their fruit. On the tree that was half sprayed the difference between the two sides was as marked as between the sprayed and unsprayed trees. If the spraying had been done a month earlier it is reasonable to suppose that with proper care in application the rot could have been almost entirely prevented.

Where copper remedies are used for black rot or mildew it is not likely that the grapes are in danger from the ripe rot, and in cases where no remedies have been used, two or three sprayings will probably protect the grapes. For this it will not be necessary to go to the expense of preparing the Bordeaux mixture, but the ammoniacal solution or even the potassium sulphide will probably be satisfactory.

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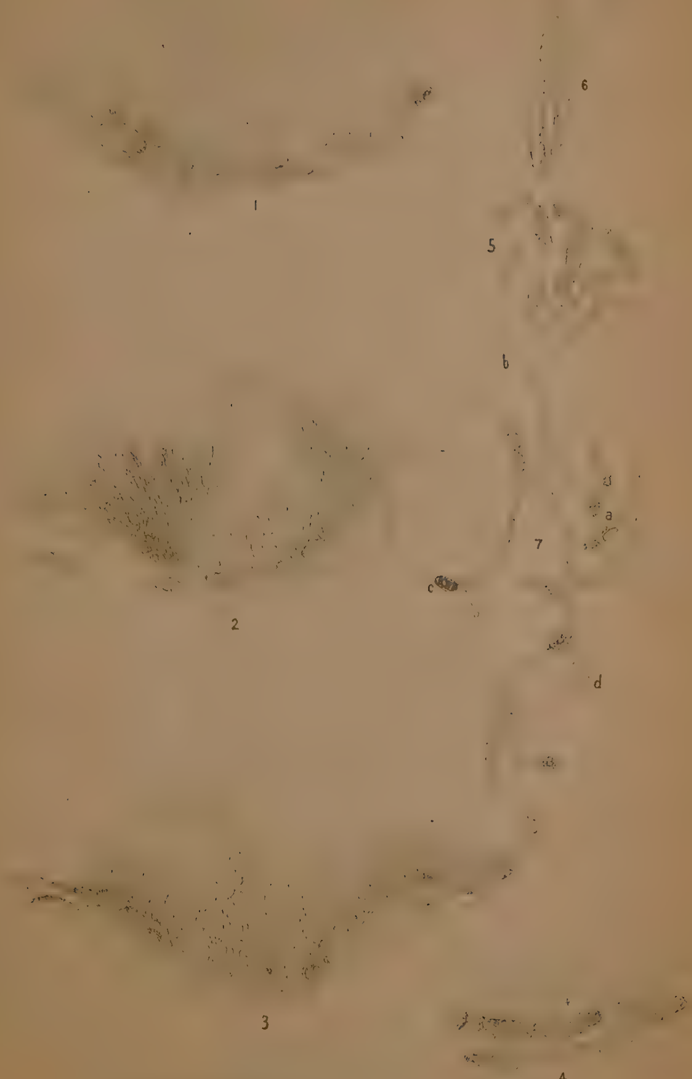
* See Diseases of the Grape in Western New York. Journal. Vol. VI, No. 3, p. 99. Referred to as the Grape glœosporium.



Southworth on Ripe Rot of Grapes and Apples.

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DESCRIPTION OF PLATE.

FIG. 1. Stroma mass broken through the epidermis. Drawn from specimen, soaked in potash, which caused the ends of the hyphæ to swell and the spores, if there were any, to fall off.

FIG. 2. A later stage. The central part of the stroma mass has begun to break down and spores to form around the circumference.

FIG. 3. Still later stage in the same process.

FIG. 4. Glœosporium form of fungus.

FIG. 5. Spores; three on basidia.

FIG. 6. Setæ.

FIG. 7. Germinating spores; some producing secondary spores on hyphæ.

ANTHRACNOSE OF COTTON.*

PLATES XVII, XVIII.

By GEORGE F. ATKINSON.

While investigating the disease of cotton popularly called "black rust" and "red rust," I found upon an old leaf scar of a cotton stalk a fungus, the spores of which in mass are of a roseate tint. The spores were produced in small clustered heaps, which at length broke through

* Paper read before the American Association of Agricultural Colleges and Experiment Stations. Champaign, Ill., November 11–13, 1890.

to the surface. The fungus resembled very closely members of the genus *Glœosporium.* Farther investigation showed that older specimens possessed olive or dark-brown setæ, intermingled with the colorless basidia. The setæ are proportionately few where the substratum is soft, more numerous when it becomes hard or in the dead or nearly dried parts of the plant, particularly on the stems and the dissepiments of the open boll. The presence of setæ shows the affinity of the fungus with the genus *Colletotrichum.*

On the green bolls the fungus produces depressed spots, at first of a black color, caused by the death of the tissues. If the weather is favorable for the development of numerous spores the dark depressions later assume a grayish or roseate tint from the lesser or greater mass of spores developed. Sometimes the depressions are not well marked, but the fungus being evenly distributed gives a black color to a large portion of the surface of the boll. A severe attack seems to hasten a premature partial opening of the boll, but frequently this checks the growth and the lint can not escape. In such cases the fungus frequently grows also on the lint. Besides these characteristic effects on the boll, the fungus severely injures other parts of the plant. It is a very common accompaniment of *Cercospora gossypina*, Cooke, and other fungi of "black rust" on the leaves, and does much to aggravate that disease. So early as August 12 I found it upon the leaves, and it probably occurred earlier.

The *Colletotrichum* also occasions a very distinct and destructive disease of the cotton plant. A remarkable example of this occurred on the Station farm in some cotton planted in "checks," *i. e.*, in hills with the rows running both ways. The portion of the field attacked was about 2 or 3 acres in extent. During August I noted on my weekly visits that the usual fungi of "black rust" and "red rust" were present, but not sufficient in extent to do any appreciable injury nor to characterize these diseases as they are known to the farmers of Alabama. I found also the *Colletotrichum* principally on the edges of the leaves. In September the *Colletotrichum* severely attacked the stems of the upper part of the plant. The leaves soon appeared, as some expressed it, as if they were affected with a "scald," changing to various shades of yellowish or leaden green color. They soon withered and dried much as if killed by frost, presenting a decidedly different appearance from leaves killed by black rust. The stems became blackened and the death of the plant usually followed.

I have observed the same characteristic disease in several localities around Auburn, but this patch of 2 or 3 acres is the largest I have met with. It is not improbable that in some of the cases reported as "black rust," where in the first stages of the disease it sweeps rapidly and suddenly over certain spots, the *Colletotrichum* is the ultimate factor in causing the death of the plant, and then frequently continues the disease upon the bolls.

Characters of the fungus.—The spores are oblong, usually rather sharply pointed at the base, often rounded at both ends, with a broad shallow constriction in the middle, nearly cylindrical or distinctly curved, sometimes "binucleate." They vary greatly in size from 4.5 to 9μ in diameter by 15 to 20μ in length. Where they are produced on green or decaying bolls, or other softened parts of the plant the distinct acervuli are 100 to 150μ in diameter. On the leaves the acervuli are much smaller and very rarely in sufficient quantity to give the roseate tint. I have found one case of the fungus on a cotyledon of a young plant where the color was distinctly produced. The cotyledons, however, are much more succulent than the leaves. It had also been raining for several days, so that the diseased part could not dry and thus check the profuse development of spores. Many of the spores are borne on scattered fertile hyphæ within the tissues of the leaf, not being collected into distinct clusters. As the tissues of the plant become harder by the partial drying of the leaf the spores produced are fewer in number and borne mainly upon the ends of the setæ.

The setæ are olive or dark brown, straight, curved, flexuous, or rarely branched. They arise from especial bodies, resembling somewhat an imperfect sclerotium, composed of a single dark-brown cell or of a varying number of dark-brown cells, generally a few. When of several cells it is irregular in shape. It is situated within the tissues of the host or projects slightly above the surface or lies along between the cells of the epidermis. When the body consists of a single cell it is produced at the end of a hypha, but is greater in diameter. These single cells may increase to the several-celled sclerotia by a process of growth similar to budding, except that the cells thus formed remain in a closely compact body. The end cells of the setæ are nearly hyaline. The spores borne upon them are often oval, the base being rather sharply pointed. The setæ vary in length from 100 to 250μ. They are usually decidedly shorter on the leaves than on the other parts of the plant. They are in clusters of 5 to 10, or more. Frequently the clusters are so numerous as to make it appear that the setæ are evenly distributed over the substratum.

Artificial cultures.—A number of artificial cultures were made to trace the development of the setæ and the peculiar bodies which bear them. The nutrient medium in most cases was agar peptone broth and an infusion of cotton leaves. Pure cultures were obtained by placing bolls on which the spores were just being produced in a moist chamber. When the cluster of spores was well elevated and distinct, not so old as to be contaminated with bacteria, with a flamed needle a few spores could usually be taken not accompanied by other germs.

The cultures were made in cells. The spores germinated quite freely within 12 to 15 hours, possibly much sooner under favorable conditions. At the time of germination, or prior to it, frequently one or two transverse septa are found in the spore, dividing it into two or three cells.

Several germ tubes may be produced from a single spore. The mycelial threads begin to branch immediately and are somewhat flexuous in their course. From all parts of the mycelium short fertile branches soon arose of 1, 2, or 3 cells' length, which resemble the basidia and produce spores. Sometimes these fertile branches or basidia arise directly from the spore. In the solid medium the spores from a single basidium, when not crowded by the basidia and other spores, are clustered around the end. Each succeeding spore pushing the one which has just become free to one side. The sharply pointed basal end of the spore favors this. After several days there is a beautiful crown cluster of spores about the end of the basidium, all lying parallel to each other. Spores are sometimes produced within 24 hours from the time of sowing.

Besides the production of spores, certain of the branches, either near, or remote from, the center of growth, produce at their ends peculiar enlarged cells, olive brown in color, varying in their outline, but always of greater diameter than the hyphæ which produce them. These bodies frequently produce immediately a normal hypha resembling the others of the mycelium. This in turn may soon produce another special cell, or may grow to considerable length, produce basidia and spores, or as a basidium or fertile hypha direct from the special cell produce spores. In other cases the special cell immediately begins to bud in an irregular manner, producing cells similar in color but very closely compacted into an irregular oval or elongated or flattened imperfect sclerotium. After one or two weeks' growth a large number of these special cells and imperfect sclerotia are produced near the center of growth, *i. e.*, original spore. At the same time the basidia have become very numerous at this point, arising from the mycelium or by the branching of the older ones, and the mass of spores assumes the roseate tint. In several cases I have been able to have the production of the dark-brown setæ borne on these special bodies or cells in the artificial cultures.

Cultures were also started in pure water and in a weak nutrient medium. In water the germ tubes, almost invariably, when once or twice the length of the spore, produced the special cell. If these produced another tube it was only to give rise to another cell of the dark color. In no case were spores produced nor any appreciable length of mycelium. In the weak nutrient medium the special cells were produced freely. Also a number of hyphæ produced one to four or five spores. While the vegetative growth exceeded that of the spores sown in pure water, there was but little compared with the growth in a rich nutrient medium, and the spores did not seem to live long.

These special dark-brown cells, produced soon after germination more freely in weak nutrient media, remind one of secondary spores, but the fact that they are produced in rich nutrient media when ordinary spores are abundant, and especially since they grow by an irregular process of budding to cellular bodies resembling sclerotia, and in both cases

produce setæ, seems to favor the notion that they may serve as peculiar resting bodies produced more abundantly in unfavorable conditions, and later capable of producing mycelia again.

I have observed these same peculiar cells preceding the formation of sclerotia, and intermingled with them in the case of *Vermicularia circinans* on the onion. This is additional testimony regarding the close relationship existing between some of the species of *Colletotrichum* and *Vermicularia*.

Parallel with the artificial cultures, inoculations were made of seedlings grown in a frame. A portion of a boll containing a profuse development of spores was immersed in distilled water which was then shaken thoroughly. The cotyledons of the plantlets were well wetted with this. A bell jar was then placed over them for twenty-four hours. An attempt was then made to imitate as nearly as possible the natural conditions of temperature and humidity, which seem to favor the early development for a few days. By artificial heat temperatures ranging from night to midday, 20° to 35° C. were produced. The humidity of the air in the frame was also kept above that of the open air by keeping the frame closed, having but little ventilation and wetting the soil daily. After the fourth day the humidity was reduced while the temperature was maintained. It was not found necessary to inoculate at incisions in parts of the plant.

A week later an examination was made of a cotyledon which was dying, the distal end being half dead and shriveled while the base was still green. It was well infected, and there were numerous clusters of setæ at the edge, also clusters of spores, and in the interior of the cotyledon spores borne on scattered basidia. Ten days from the time of inoculation another plantlet was diseased, both cotyledons being affected. When the distal half was pretty well dead and shriveled the examination was made. Very few external signs of the fungus were present, but in a few places at the edge the setæ were just piercing through, and sections showed numerous spores and clusters of the special bodies which bear the setæ. The base of each cotyledon was apparently healthy and each was still firmly attached to the stem.

I have not yet attempted to inoculate the plants in any other way than through the cotyledons, but the success attained has suggested that perhaps the plants when not injured in any way are only liable to infection through the cotyledons as in the well-known cases of *Cystopus candidus* in different species of *Cruciferæ*. How far this is true must be determined by future experiments.

The *Colletotrichum* on cotton seems to have been hitherto an undescribed species. Since completing this work thus far I found that Miss E. A. Southworth had been giving the fungus some study, having had specimens of it on cotton bolls. She has proposed the name *Colletotrichum gossypii*, n. sp., which is eminently appropriate.

DESCRIPTION OF PLATE.

Fig. 1. Spores showing variation in shape and size.
2. Spores germinating in artificial cultures.
3. Farther development.
4, 5, 6, 7. Spores germinating and some of the hyphæ producing the dark-brown cells.
8. Spores germinating in pure water, producing immediately the special cells.
9. Spores germinating in weak nutrient medium producing special cells and a few spores.
10. Same.
11. Growth from one spore in rich nutrient medium 65 hours from time of sowing, showing crown clusters of spores around ends of fertile hyphæ; one of the special cells by budding has produced an imperfect sclerotium.
12. Ends of hyphæ in an old culture showing special cells and one seta.
13. Section through acervuli on boll.
14. Same, more highly magnified.
15. Section from stem showing special cells and imperfect sclerotia and origin of setæ.
16. Peculiar enlarged cells from a cluster.
17. Setæ from old specimens on dried part of boll.
18. Setæ from leaf.
19. Young setæ from cotyledon of one of the plants inoculated with spores from a boll.

Figs. 2–12. From artificial cultures, 13 to 18 from natural specimens, 19 from inoculation.

All excepting 13 drawn to the same scale with aid of camera lucida. Fig. 13 drawn with aid of camera lucida to smaller scale.

MYCOLOGICAL NOTES II.

PLATE VII.

By GEORGE MASSEE.

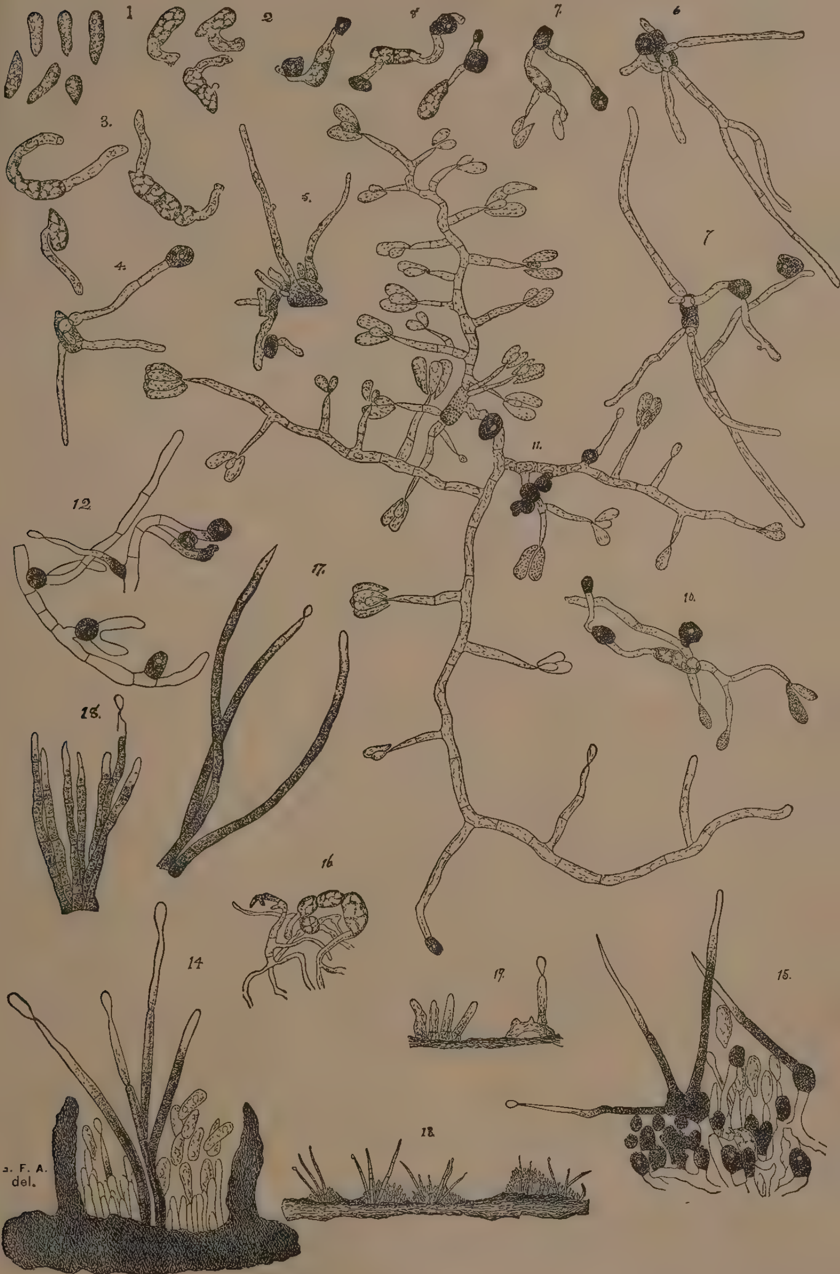
SARCOMYCES, Mass., (*nov. gen.*)

Receptacle subgelatinous, subsessile, erumpent, attached by a narrow base; hymenium convex, even, margin acute; asci cylindrical; spores uniseriate, colored, muriformly septate; paraphyses numerous.

Allied to *Hæmatomyxa*, Sacc., but distinguished by the even marginate hymenium and the uniseriate spores. It is doubtful whether the last-named genus really belongs to the *Bulgarieæ*.

SARCOMYCES VINOSA, Mass. (Figs. 1–3.) Erumpent; substipitate, expanding into a more or less circular fleshy disk, plane or convex below, margin acute, patent when moist, incurved when dry; hymenium convex, even, every part perfectly glabrous and dark purple-brown; asci cylindrical, attenuated and usually curved at the base; spores uniseriate, four in an ascus, elliptical, ends subacute, usually rather oblique, at first triseptate then with septa formed parallel to the long axis of the spore, slightly or not at all constricted at the septa, clear brown,

Atkinson on Cotton Anthracnose.



ATKINSON ON COTTON ANTHRACNOSE.

21–24 by 8–10μ; paraphyses linear, colorless, not incrassated at the tips, aseptate, equal in length to the asci, very numerous, 2–5μ thick.

Tremella vinosa, Berk. & Curt., in Herb. Berk. On wood. Venezuela; S. Carolina, Rav. Type in Herb. Berk., Kew, No. 4285.

From two-thirds to 1 inch across, solitary, or 2–3 in clusters, subgelatinous when moist, cartilaginous and much contracted when dry. With very much the habit and general appearance of *Bulgaria inquinans*, but of a dark purple color.

PEZIZA PROTRUSA, B. & C. (Figs. 8 to 11.) Hypophyllous, gregarious, erumpent, bordered by the torn, upraised cuticle; hymenium plane or concave, whitish, hypothecium very thin; margin of cup slightly raised, composed of parallel septate hyphæ, each terminated by a large, olive-brown cell; asci subcylindrical, 55–60 by 5–6 μ; spores irregularly biseriate, cylindrical, tips obtuse, smooth, colorless, 5–6 by 1.5μ, paraphyses absent.

Peziza protrusa, B. & C., Grev., Vol. III, p. 159.

Pseudopeziza protrusa, (B. & C.) Rehm, Ascom. No. 310. Sacc. Syll. VIII, No. 2980.

Pyrenopeziza protrusa, (B. & C.) Sacc. Syll. VIII, No. 1503. (Type in Herb. Berk., Kew, No. 7815.)

On the leaves of *Magnolia glauca*, Lower Carolina. Gregarious, rarely crowded, up to 0.5 millimetre in diameter. I have not been able to detect paraphyses in the specimen examined. Usually circular and patellate, the irregularity of the opening being due to the mode of rupture of the epidermis.

STAMNARIA PUSIO, (B. & C.) Mass. (Figs. 16–18.) In clusters of 2–3 from a common stem, every part horny and translucent when dry; cups urceolate or subglobose; mouth contracted, externally smooth, even, grayish, or horn colored; hymenium concave, orange, asci cylindrical, slightly narrower at base; spores 8, uniseriate, elliptic-oblong, smooth, colorless, 15 by 7–8μ; paraphyses numerous, linear, septate; the cups pass downward into slender stems which combine to form a thickened, root-like portion.

Peziza pusio, B. & C., Grev., Vol. III, p. 153; Cke., Mycogr. 106.

Sarcoscypha pusio, Sacc. Syll., Vol. VIII, No. 624. (Type in Herb. Berk., Kew, No. 7451.) On the ground. Texas. (C. Wright.)

The whole fungus 1 inch or more high; substance hard and horny when dry; hyphæ thick-walled, densely interlaced, the walls becoming gelatinous and cemented together.

PSILOPEZIA MIRABILIS, B. & C., Journ. Linn. Soc., Vol. X, p. 364; Sacc. Syll., Vol. VIII, No. 616, is synonymous with *Aleurodiscus Oakesii*. Type in Herb. Berk., No. 7402.

CYPHELLA TELA, (B. & C.) Mass. (Figs. 12, 13.)

Gregarious on a dense white subiculum; cups minute, 150–180μ diameter, subglobose; mouth at first small, becoming expanded, but the acute margin always remains more or less incurved; externally

blackish brown, frosted with glistening crystals of oxalate of lime; hymenium concave, even, naked, blackish brown; basidia clavate, tetrasperous; spores subglobose or broadly pyriform, smooth, pale brown, 7 by 5μ.

Peziza tela, Berk. & Curt., Grev., Vol. III, p. 156 (1875).

Tapesia tela, (B. & C.) Sacc., Syll. Vol. VIII, No. 1539.

On wood. Lower Carolina. (Type in Herb. Berk., Kew, No. 7724.)

The present species, owing to its dark color and gregarious habit, also being furnished with a dense, white, broadly effused, superficial mycelium, suggests the genus *Peziza* when examined under a low power, but is a true *Cyphella*.

DACRYOPSIS, Mass., (*nov. gen.*)

Small subgelatinous fungi, fertile portion capitate, sharply defined, terminal on a more or less elongated stem composed of parallel, simple or branched septate hyphæ; at the apex of the stem the hyphæ are very much interlaced, forming a compact expanded layer from which originates in the first instance numerous slender gonidiophores spreading on every side to form a more or less capitate head; gonidia minute, one-celled, forming a dense layer; basidia cylindrical, bifurcate, aseptate, springing from the interlaced layer of hyphæ at the apex of the stem, either contemporaneous with, or later than, the gonidiophores; spores simple or septate.

Coryne, Berk., Grev. Vol. II, p. 33 (in part).

Ditiola, Berk., Ann. Nat. Hist., Ser. 2, Vol. II, p. 267, Pl. IX, Fig. 4.

Tremella, Sacc. Syll. Vol. VI, p. 780 (in part).

Coryne, Sacc. Syll. Vol. VIII, p. 641 (in part).

During the gonidial stage the structure is identical with that of the form-genus *Tubercularia*, the stem is often more elongated than in the last-named genus, but in *Dacryopsis nuda* even this unimportant difference disappears. The basidia and spores closely resemble those met with in *Dacryomyces*, to which genus the present is closely allied, differing in the structure of the stem and in the arrangement and form of the gonidiophores.

The gonidial phase of *Dacryopsis nuda* is morphologically almost indistinguishable from the form species known as *Tubercularia vulgaris*, Tode, but it is well known that the latter is the gonidial condition of the ascigerous fungus called *Nectria cinnabarina*, Fr., hence it is seen that two structures almost indistinguishable in the gonidial form may be conditions of ascomycetous and basidiomycetous fungi, respectively. Again, it is known that the gonidial condition of various species of *Nectria* belongs to such morphologically distinct form genera as *Tubercularia*, *Fusarium*, *Volutella*, etc., consequently it appears to be at least indiscreet to assume, much more to assert, that because a gonidial form presenting certain morphological features has been clearly proved to be a condition of some higher fungus belonging to a given genus that

another gonidial form of similar structure must necessarily be a condition of some hypothetical species of the same genus. Such assumptions do not harmonize with the stated belief of those mycologists who consider that a complete life history is necessary to prove relationship or otherwise in suspected cases, a belief that has brought conviction to the mind of most disciples of the Friesian school, whose conceptions of affinity are based on characters derived from mature examples, which in many instances are of no genetic value. On the other hand, it is to be regretted that the modern school, having adopted the only known reliable test of affinity—life history—should endeavor to indicate affinity from analogy to such an extent as is too frequently done. The close morphological agreement between the gonidial condition in the present genus and in *Coryne* further illustrates the same idea.

DACRYOPSIS GYROCEPHALA, Mass. (Figs. 4–7.) Gregarious or scattered; head hemispherical, plane below, with ridges arranged in a gyrose manner, dark purple, blackish purple when dry; stem equal or slightly incrassate above, smooth, even, pale, tan-colored, 2–3.5 millimetres long, about 1.5 millimetre thick; gonidiophores covering every part of the head, simple, aseptate, straight, 40–50 by 1.5μ; gonidia terminal continuous, colorless, elliptic-oblong, 2.5 by 1μ; basidia projecting beyond the gonidiophores, aseptate, cylindrical, bifurcate near the apex, 60–65 by $6–7\mu$; spores continuous, colorless, elliptic-oblong, slightly curved, with an oblique apiculus at the base, 15–16 by $4–4.5\mu$; clavate paraphyses numerous, shorter than the gonidiophores.

Tremella (*Coryne*) *gyrocephala*, B. & C., Grev., Vol. II, p. 20 (1873). Sacc. Syll., Vol. VIII, No. 2654. (Type in Herb. Berk., Kew.) Lower Carolina. Gregarious, on rotten wood.

The stem attains its full size before the development of the head commences, the latter is at first small and even, but as it increases in size becomes gyrose as in many species of *Tremella* and *Dacryomyces*.

In old specimens the gonidiophores have fallen away, leaving only the basidia and paraphyses.

DACRYOPSIS ELLISINA, Mass. (Figs: 19–21.) Gregarious, head broadly elliptical or elliptic-oblong, smooth, even, pale brown, 4–6 by 2–4 millimetres, stem cylindrical, longitudinally wrinkled, 3–4 by 1.5–2 millimetres, dark brown; gonidiophores covering the entire head, straight, septate, with 1–3 short branchlets near the apex, 40–50 by 2.5μ; gonidia continuous, colorless, elliptic-oblong, very slightly curved, 3 by 1μ; basidia cylindrical, bifurcate at the apex, aseptate, 50–55 by 6μ; spores elliptic-oblong, with an oblique apiculus at the base, 14 by 5μ.

Coryne Ellisii Berk., Grev., Vol. II, p. 33; Sacc. Syll., Vol. VIII, No. 2655. Potsdam, New York. (Ellis.) On decaying basswood log. (Type in Herb. Berk., Kew.)

DACRYOPSIS UNICOLOR, Mass. (Figs. 22–24.) Gregarious; entire fungus, blackish brown; head globose, small, smooth, even, 1.5–2 millimetres diameter; stem elongated, erect, slightly attenuated upwards,

vaguely longitudinally rugulose, 5–8 by 1–1.5 millimetres; gonidiophores covering every portion of the head, linear, curved, septate, with a few short lateral branchlets, 70–80 by 1.5μ; gonidia elliptic-oblong, continuous, colorless, 3–1μ; basidia appearing after the gonidiophores, aseptate, bifurcate at the apex, 45–50 by 5–6μ; spores continuous, colorless, elliptic-oblong, with an oblique apiculus at the base, 15 by 4–4.5μ.

Coryne unicolor, B. & Curt. Type in Herb. Berk., Kew, No. 4310. On rotten wood, Cuba. (Wright.)

I have not seen any previous description of the present species; possibly such may exist along with others of the same genus in some American publication.

Dacryopsis nuda, Mass. (Figs. 25–26.) Gregarious; head hemispherical, flattened below, at first even, then minutely rugulose, reddish orange, 3–4 millimetres diameter; stem short, stout, equal, white, or tinged with yellow, minutely tomentose, 3–4 by 2–2.5 millimetres, even; gondiophores appearing before the basidia, linear, straight, aseptate, simple, or rarely with one or two short branchlets near the apex, 35–40 by 1.5μ; gonidia elliptic-oblong, continuous, colorless, 3 by 1μ; basidia projecting considerably above the gonidiophores, cylindrical, bifurcate at the apex, 55–60 by 5–6μ; spores elliptic-oblong, colorless, with an oblique apiculus at the base, triseptate, 14 by 5μ.

Ditiola nuda, Berk. Ann. Nat. Hist., Ser. II, Vol. II, p. 267, Pl. IX, Fig. 4 (Berkeley's No., 375). Britain. On fir stumps.

Closely resembling in general appearance *Tubercularia cinnabarina*, but quite distinct morphologically.

Dacryomyces enata, (B. & C.), Mass. (Figs. 14, 15.) Erumpent; dark amber, appressed, surface slightly rugulose or almost smooth, bounded by the ruptured bark, up to 1 centimetre diameter; basidia cylindrical, bifurcate at the apex, 45–50 by 5μ; spores elliptic-oblong, colorless, with an oblique apiculus at the base, slightly curved, 10–11 by 3.5μ.

Tremella enata, Berk. & Curt., Grev., Vol. II, p. 20; Sacc. Syll., Vol. VI, No. 8424. Superficially resembling a small discolored form of *Tremella albida*, but a true *Dacryomyces*. From 3 millimetres to 1 centimetre across. Type in Herb. Berk., Kew, No. 4307. On *Alnus serrulata* and oak, lower Carolina.

Tremella vesicaria, Bull. = *Peziza concrescens*, Schweinitz. (Specimens from Schweinitz in Herb. Berk.)

Tremella gigantea, B. & C., Grev., Vol. II, p. 19. Alabama. (Peters.) The present species is a gelatinous lichen. Type in Herb. Berk., Kew, No. 4260.

Tremella myricæ, Berk. & Cooke. Foliaceo-gyrose, gelatinoso-elastic, semipellucid, smoky gray, when dry blackish with a tinge of purple here and there, surface with minute, scattered points; spores broadly elliptical, with an oblique apiculus, 8–9 by 6–7μ, colorless.

Tremella myricæ, Berk. & Cke., Grev., VI, p. 133; Sacc. Syll., VI, No. 8422. On bark of *Myrica* and *Persea*, Gainesville, Fla. (Rav.). (Type in Herb. Berk., Kew, No. 4300.)

Forming thin, foliaceous expansions when dry, 1–4 centimetres across. The minutely scabrid surface when dry is characteristic.

DACRYMYCES SYRINGICOLA, B. & C. Erumpent, pale or slightly convex, surface almost even or tuberculated, watery gray or whitish, surrounded by the ruptured epidermis; basidia large, spherical, with four stout, elongated sterigmata, spores colorless, cylindric-oblong, curved, with an oblique apiculus at the base, 32–35 by 8–9μ.

Dacrymyces syringicola, B. & C., Grev., Vol. II, p. 20; Sacc. Syll., VI, No. 8504.

Dacrymyces destructor, B. & C., Grev., Vol. II, p. 20; Sacc., Syll. VI, No. 8505. Both types in Herb. Berk., Kew., Nos. 4324 and 4328.

On *Syringa* and on branches of pear, to which it is very destructive, lower Carolina. Rav.

The only distinction between the two species, as pointed out by Berkeley, depends on the amount of tuberculation of the surface, and even this is not constant. The furcate spores alluded to by Berkley are portions of the septate hyphæ that have become free. Circular or elliptical, often numerous, 3–4 millimetres across, resembling lenticels when dry and contracted.

TREMELLA DEPENDENS, B. & C. Pendulous, elongato-clavate, attached by a slender stem-like base, mucilaginous, pale dingy yellow; the central portion consisting of exceedingly thin hyphæ immersed in mucilage; towards the even surface the hyphæ become thicker and form a compact layer which produces basidia at every part of the surface; basidia spherical with four elongated sterigmata; spores elliptic-oblong, smooth, colorless, 7 by 3–3.5 μ.

Tremella dependens, B. & C., Grev., Vol. II, p.19; Sacc. Syll., Vol. VI, No. 8396. Hanging down from under side of rotten poplar (*Liriodendron*) logs after rain, Alabama. Peters.

The following note accompanied the specimens:

"Sack-like, elongated, round, subclavate, subtranslucent, thin, watery, mucilaginous, dissolving when the thin outer skin is broken, pale, watery, greenish-yellow, ⅛–1 inch long." The green tinge is due to minute algæ.

TREMELLA RUFO LUTEA, B. & C. A very remarkable form, attached laterally by a broad base, imbricated, resembling *Stereum hirsutum* in habit; more or less reniform or semicircular, margin sometimes lobed, yellow brown or amber, translucent when moist, upper surface irregularly nodulose and with a tendency to form concentric zones due to the arrangement of the nodules, under surface almost smooth; substance thick, very cartilaginous, central portion composed of much-branched hyphæ with thick gelatinous walls; toward the outside, above and below, the hyphæ are dense and parallel, but showing no trace of

differentiation into basidia or gonidiophores. From 4–6 by 3–4 centimetres, and 3–4 milimetres thick at the base, thinner toward the margin. Every portion perfectly smooth. Berkeley's remark "uno puncto affixa," must have been a slip of the pen.

Tremella rufo-lutea, B. & C., Journ. Linn. Soc., 1869, Vol. x, p. 340; Sacc. Syll., Vol. vi, No. 8394.

DESCRIPTION OF PLATE.

1. *Sarcomyces vinosa*, section, natural size.
2, 3. Ascus, spores, and paraphyses of same, X 400.
4. *Dacryopsis gyrocephala*, natural size.
5. Same, X 6.
6, 7. Portion of hymenium and spores of same, X 400.
8. *Peziza protrusa*, X 75.
9. Portion of hymenium and margin of same in section, X 400.
10. Asci and spores of same, X 400.
11. Spores of same, X 1,200.
12. *Cyphella tela*, X 75.
13. Portion of hymenium of same, X 400.
14. *Dacryomyces enata*, natural size.
15. Spores of same, X 400.
16. *Stamnaria pusio*, natural size.
17, 18. Ascus, paraphyses, and spores of same, X 400.
19. *Dacryopsis Ellisiana*, natural size.
20. Section of portion of hymenium of same, X 400.
21. Gonidiophores and gonidia of same, X 1,200.
22. *Dacryopsis unicolor*, natural size.
23. Gonidiophores and gonidia of same, X 1,200.
24. Spores of same, X 400.
25. *Dacryopsis nuda*, natural size.
26. Section of portion of hymenium of same, X 400.

INDEX TO NORTH AMERICAN MYCOLOGICAL LITERATURE.

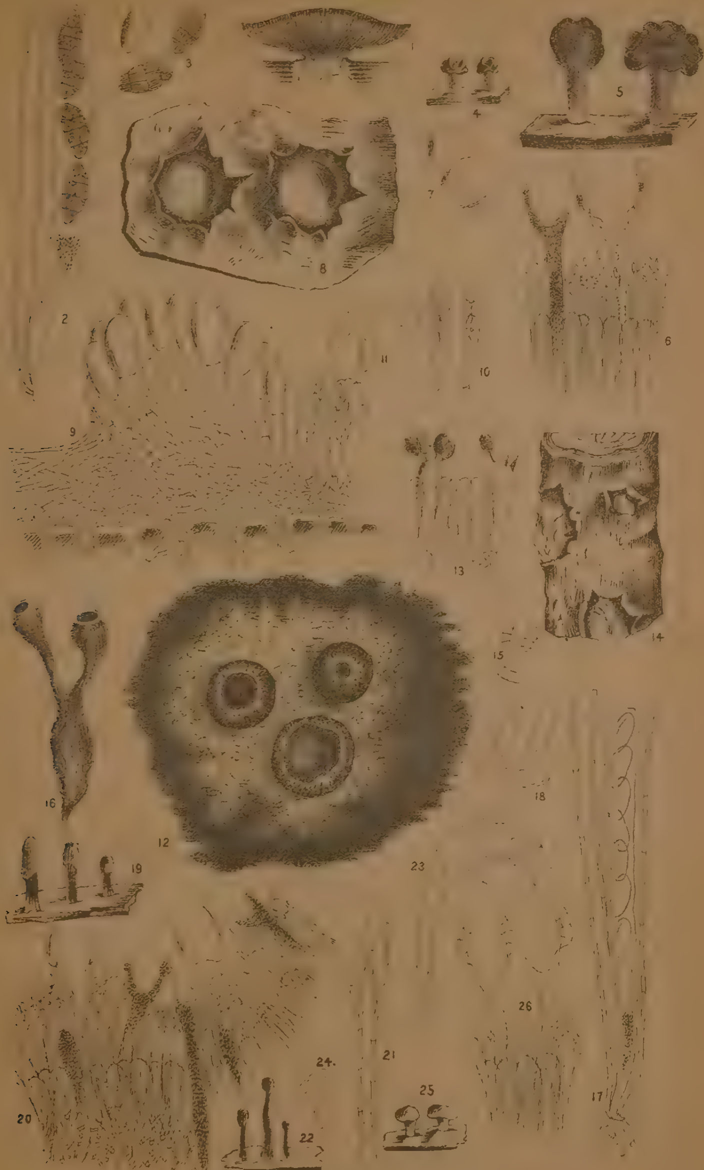
By David G. Fairchild.

177. Anderson, F. W. Biographical sketch of J. B. Ellis. Bot. Gaz. Crawfordsville, Indiana, Vol. xv, No. 11, November, 1890, pp. 299–304. Gives an account of the life of this pioneer of North American Mycology.

178. Bailey, L. H. Peaches and yellows in the Chesapeake country. American Garden, New York, January, 1891, Vol. xii, No. 1, pp. 20–23. Describes conditions of the disease in Maryland and Delaware. Refers to late investigations of the Division of Vegetable Pathology, showing disease to be of contagious nature not affected by fertilizers.

179. ———. The peach yellows. Bull. xxv., Cornell Agr. Ex. Sta. Ithaca, New York, December, 1890, pp. 178–180. Gives account of work of Dr. Erwin F. Smith, of the Department of Agriculture, upon the disease, with note as to the New York State law in regard to the matter.

180. Bessey, Chas. E. An old botanical letter. Am. Nat., December, 1890, Vol. xxiv, No. 288, p. 1196. Gives verbatim copy of a letter written by C. H. Persoon to Sowerby, from Göttingen, May 2, 1801, alluding to the latter's "English Fungi."



G.M. del. G. MASSEE. MYCOLOGICAL NOTES.

181. ———. **The host index of the fungi of the United States.** Am. Nat., XXIV, No. 288, December, 1890, p. 1196. Notices work of Farlow and Seymour with word of commendation. (See 126.)
182. ———. **Some bad station botany.** *Ibid.*, p. 1197. Criticises bulletin of Ohio Experiment Station upon wheat smut.
183. ———. **Wheat smut.** *Ibid.* Notices excellent work of Kellerman and Swingle in Bull. 12 of Kans. Ag. Experiment Station. (See 157.)
184. ———. **North American species of Tylostoma.** *Ibid.*, p. 1199. Refers to work by A. P. Morgan upon the revision of the genus *Tylostoma*.
185. ———. **New North American fungi.** *Ibid.* (See 124.)
186. BOYLE, D. R. **A parasitic fungus.** The Microscope, November, 1890, Vol. X, No. 11, p. 343. Note given of discovery at Cape Breton of larva of May beetle attacked by fungus arising from the head. (Name not given.) Specimen sent to Nova Scotian Institute of Natural Sciences by Mr. Boyle.
187. BRAIARD, MAJOR. **Champignons nouveaux.** Revue Mycologique, Toulouse, October, 1890, No. 48, p. 177. Describes *Physalospora pseudo-pustula* (Berk. & Curt.) Braiard & Hariot, (*Sphæria pustula*, B. & C.) on rotten leaf from United States, Farlow, legit.
188. BURRILL, T. J. **Preliminary notes upon the rotting of potatoes.** Proc. Eleventh Ann. Meeting Soc. for Promotion of Agricultural Science, Indianapolis, Indiana, August, 1890. Notes as genetically connected with the rot of Irish potato tubers a species of bacterium, and records its isolation on culture media with inoculations upon healthy tubers.
189. ———. **A bacterial disease of corn** (with fig.). Third Ann. Report of Illinois Ag. Ex. Sta., 1889–1890 (issued 1890). Extract from Bull. No. 6, Illinois Ag. Ex. Sta. Mentions inoculation experiments with pure cultures of bacterium as causing disease, with opinion that the same germs may cause death of cattle when diseased corn stalks are eaten.
190. COOKE, M. C. **Some exotic fungi.** Grevillea, June, 1890, Vol. 18, No. 88, p. 86. Describes *Lizonia sphagni*, n. s., on dead *Sphagnum* from Maine and *Valsa* (*Eutypella*) *clavulata*, n. s., on *Ailanthus* bark. Collected by Mrs. Britton on Staten Island.
191. ———. **North American fungi,** Grevillea, September, 1890, Vol. XIX, No. 89, pp. 14–15. Describes *Cyphella fumosa*, n. s. On rotting leaves of *Gladiolus*, South Carolina, *Rhabdospora sabalensis*, n. s., on *Sabal*, South Carolina. *Stilbum* (*Ciliciopodium*) *aurifilum*, Gerard., on *Dædalea unicolor*, United States, and *Uredo amsoniæ*, n. s., on *Amsonia*, South Carolina.
192. DUDLEY, W. R. **The hollyhock rust** (with fig.). Bull. XXV, Cornell Ag. Ex. Sta., Ithaca, New York, December, 1890, pp. 154–155. Gives popular description of *Puccinia malvacearum*, Mont., suggesting as a remedy permanganate of potash, two tablespoonfuls of saturated solution to 1 quart of water; applied with a sponge.
193. ELLIS, J. B., AND EVERHART, B. M. **The North American Pyrenomycetes.** A contribution to mycologic botany. Bull. Torrey Bot. Club, New York, January 1891, Vol. XVIII, No. 1, p. 31. Give notice of subsequent appearance of the work by placing advance sheets in the hands of the editors of the Bulletin.
194. GALLOWAY, B. T. **Note on the nomenclature of Uncinula spiralis, B. & C.** Bot. Gaz., December 26, 1890, Vol. XV, No. 12, p. 339. Gives correct synonymy of the species, preferring *Uncinula spiralis*, Berkeley & Curtis, 1857.
195. ———. **Some recent observations on black rot of the grape.** *Ibid.*, pp. 60–63. Gives the results of three experiments to prove the relationship between *Phyllosticta labruscæ*, Thüm., *P. ampelopsidis*, E. & M., and *Læstadia Bidwellii* (Ell.) V. & R. Records characteristic *Phyllosticta* spots upon *Ampelopsis* and *Vitis* from sowings of ascospores of *Læstadia Bidwellii* (Ell.), V. & R., and entirely negative results from all sowings of pycnidia spores. (See 130.)

196. ——— and Fairchild, D. G. **A comparative test of some of the copper preparations in the treatment of black rot of grapes.** Proc. 11th Ann. Meeting Society for the Promotion of Agricultural Science, Indianapolis, Indiana, August 18, 19, 1890, pp. 59, 60 (issued December, 1890). Give result of experiments in Virginia to test comparative efficacy of Bordeaux mixture, ammoniacal solution of copper carbonate, copper carbonate in suspension, and combination of Bordeaux mixture and ammoniacal solution of copper carbonate, three treatments of the former, five of the latter. Conclude Bordeaux to have saved the largest per cent of fruit, but ammoniacal solution to be most economical.

197. Garman, H. **Some strawberry pests; the strawberry leaf-blight fungus.** Bull. 31, Kentucky Ag. Ex. Sta., December, 1890, Lexington, Kentucky, pp. 3–13. Describes disease with figures giving results of careful experiments with Bordeaux mixture, eau celeste, liver of sulphur, and London purple as preventives. Concludes Bordeaux, applied at intervals of two weeks after removal of berries, most effective in prevention of *Ramularia Tulasnei*, Sacc., eau celeste standing second, and London purple, although better than no fungicide, standing last. Thinks the removal of diseased leaves in summer, if not followed by fungicidal applications, more injurious than beneficial, because lessening shade to young leaves.

198. Hall, Clifford C. **Stinking smut of wheat.** The Modern Miller, Kansas City, Missouri, October 1890, Vol. 14, No. 9, p. 255 (with fig. from Bull. 12, Kans. Ex. Station). Gives short extract from Bull. 12, Kans. Ag. Ex. Station, 1890. (See 157.)

199. Halsted, B. D. **Some fungous diseases of the sweet potato.** Bull. 76, New Jersey Ag. Ex. Station, New Brunswick, New Jersey, November 28, 1890 (with numerous figures). Describes, with figures and recommendations for treatment, soft rot, (*Rhizopus nigricans*, Ehr.), black rot (*Ceratocystis fimbriata*, Ell. & Hals., n. s.) soil rot, (*Acrocystis batatus*, Ell. & Hals., n. s.) stem rot, white rot (*Penicillium*, sp.), dry rot, (*Phoma batatæ*, Ell. & Hals., n. s.) scurf, (*Monilochætes infuscans*, Ell. & Hals. n. s.) leaf-blight (*Phyllosticta bataticola*, E. & M.), leaf mold [*Cystopus ipomææ-panduranæ*, (Schw.) Farl]. A very valuable bulletin of monographic nature, to furnish a basis for experimental work upon the diseases of this important crop.

200. ———. **Notes upon Peronosporeæ for 1890.** Bot. Gaz., December 26, 1890, Vol. xv, No. 12, pp. 320–324. Gives notes of abundance, destructiveness, and previous mention in America of the following: *Phytophthora infestans*, DBy.; *P. phaseoli*, Thax.; *Plasmopara viticola*, (B. & C.), Berl & DeT., on *Vitis*, *Ampelopsis tricuspidata*, and *A. quinquefolia*; *P. Entospora*, Schrœt, on *Erigeron Canadense*; *P. geranii*, (Peck) Berl., on *G. Carolinianum*; *Bremia lactucæ*, Regel, on *L. Canadensis*; *P. parasitica*, DBy., on *Cardamine, hirsuta*, *C. laciniata*, *Hesperis matronalis*, and outer leaves of cabbage; *P. violæ*, DBy., on *Viola*, sp.; *P. Cubensis* on cucumbers; *P. effusa* on *Spinacea*; *P. Ficariæ*, Tul., on *Ranunculus abortivus*; *P. alta*, Fl., on *Plantago major*, *P. lanceolata*, and *P. Virginica*; *P. obovata*, Bonord. on *Spergula arvensis* found with *Puccinia spergulæ*, DC., a new rust to this country; *Cystopus ipomææ-panduranæ*, (Schw.) Farl.

201. ———. **A new anthracnose of peppers** (with fig.). Bull. Torr. Bot. Club, Vol. xviii No. 1, pp. 14–15. Describes as new *Colletotrichum nigrum*, Ellis & Halsted, which attacks and causes serious damage to the fruits of *Capsicum annuum* in New Jersey.

202. ———. **The rot among late potatoes.** Garden and Forest, New York, November 12, 1890, Vol. iii, No. 142, p. 551 (1 column). Notes destructiveness in New Jersey in 1890. Recommends spraying with copper compounds.

203. ———. **The root rot of salsify.** Garden and Forest, New York, November 26, 1890, Vol. iii, No. 144, p. 576 (1 column). Notes disease of salsify closely connected with bacteria; which bacteria are able to cause rot in the egg plant, sweet potato, white potato, onion, and apple. The germ not isolated in cultures.

204. ———. **The cranberry scald** (with figs.). Garden and Forest, New York, December 3, 1890, Vol. III, No. 145, p. 583 (2 columns). Gives account of the scald with conditions probably favorable to the development of the disease, as decaying vegetation and stagnant water.

205. ———. **The mignonette disease.** Garden and Forest, New York, January 21, 1891, Vol. IV, No. 152, p. 33 (half column). Notes destructive case of *Cercospora resedæ*, Fckl., upon hot-house mignonette, recommending Bordeaux mixture as preventive.

206. ———. **The potato rot; its nature, and suggestions for checking it in the future** (with fig.). Rural New Yorker, New York, Vol. XLIX, No. 2129, p. 771, November 15, 1890. Popular exposition of subject, suggesting remedies.

207. ———. **The rots of the sweet potatoes.** Proc. 11th Ann. Meeting Society for the Promotion of Agricultural Science, Indianapolis, Indiana, August 18, 19, 1890, pp. 27–28 (issued December, 1890). (Abstract.) Discusses briefly ground rot, soft rot, black rot, or black root, yellow rot or stem rot, and dry rot, giving general characters and results of investigation. Notes *Rhizopus nigricans* as cause of soft rot and *Penicillium* as cause of dry rot.

208. HARIOT, P., AND KARSTEN, P. A. **Micromycetes novi.** Revue Mycologique, Toulouse, July, 1890, No. 47. Describes *Calosphæria smilacis*, Kars. & Har., on *Smilax* from Ohio, legit Lesquereux. *Cornularia Rhois*, (Berk.?) Karst. *Sphæronema Rhois*, Berk. Syn.? On *Rhois* from Ohio, legit Lesquereux; *Phoma picea* (Pers.) Sacc., var. *chenopodii*, Karst & Har. on *Chenopodium* from Ohio, Lesquereux legit.

209. HOWELL, J. K. **The clover rust** [*Uromyces trifolii*, (Alb. & Schw). Wint.]. Bull. XXIV, December, 1890. Cornell Univ. Ag. Ex. Sta., Ithaca, New York, pp. 129–139. (with figs.). Note by W. R. Dudley. Gives occurrence, distribution, and injuriousness of the parasite, with careful description of vegetative and reproductive organs and observations on development: also, an account of artificial cultures and infections. Concludes the fungus to be propagated throughout the growing season by *Uredo* spores, which prefer a low temperature in germination, and are genetically connected with the æcidial stage.

210. JONES, L. R. **The potato rot and apple scab.** Newspaper Bull. No. 2, Vermont Agr. Ex. Sta., Burlington, Vermont, 1890. Popular description of fungi causing diseases, with formulæ for copper compounds and directions for treatment.

211. KELLERMAN, W. A. **More about smut of oats.** Industrialist, Manhattan, Kansas, January 24, 1891, Vol. XVI, No. 18, p. 69 (1½ columns). Announces the preparation of Bull. 15, Kans. State Agr. Ex. Station to appear subsequently. Records the discovery of quantities of hidden smut in plats of oats, pointing to a too low estimate of injury. Claims for the Jensen hot-water method augmentation of oat crop in excess of that due to prevention of the smut, mentions as promising fungicide, one-half per cent solution of potassium sulphide, 1 pound to 24 gallons of water, leaving seed in the solution 24 hours. Gives as probable loss from smut in Kansas for 1888–'89–'90 a little less than six millions of dollars.

212. ——— AND SWINGLE, W. T. **Preliminary experiments with fungicides for stinking smut of wheat.** Report of Kansas State Board of Agr. for month ending August 31 (issued October 1, 1890), pp. 5–29, with plate. Reprint Bull. 12 of Botanical Dept. Agr. Ex. Sta., Manhattan, Kansas, August 1890 (issued October 1). (See 157.)

213. LAGERHEIM, G. DE. **Note sur un nouveau parasite dangereux de la Vigne** (*Uredo Vialæ*, sp. nov). Comptes Rendus, Paris, Tome CX, 1890, p. 728, and Rev. Gen. de Bot., September 15, 1890. Describes *Uredo Vialæ* as a new Uredineæ upon leaves of *Vitis* found in Jamaica near Rockfort. Decides it entirely different from *U. vitis*, Thüm., which is not a fungus. Of special interest as the first recorded *Uredineæ* upon *Vitis*. Name in honor of P. Viala.

214. LELONG, B. M. **Fungous growths.** Thirteenth Ann. Report of Secretary of California State Board of Agr. Supplement, pp. 242–249 (with 1 lith. plate). Gives general description of fungi, quoting from Harkness, California State Board of Hort, 1883, and treats of Shot-hole apricot fungus (*Septoria cerasina*, Pk.) (with fig.), mentioning spread of disease to peach, plum, prune, and even apple and pear trees adjacent to apricots. Suggests various remedies. Pear cracking and leaf-blight (*Entomosporium maculatum*, Lév.) (with figs.), quotes from Galloway's report, U. S. Dept. Agriculture, both as to fungus and remedies. Recommends as most successful remedy applied both for scale and fungus, sulphur 3 pounds, caustic soda (98 per cent) 2 pounds, whale oil soap, 25 pounds made up to 100 gallons. Apple scab [*Fusicladium dendriticum*, (Wallr.) Fckl.] (with fig.), gives summary of description and treatment of diseases in Report of U. S. Dept. Agr. 1887, also results of Professor Taft's Experiments, in Bull. 11, Div. Veg. Path., U. S. Dept. Agr. (See 104.)

215. MAYNARD, S. T. **Fungicides and insecticides on the apple, pear, and plum.** Bull. No. 11. Mass. Hatch Ex. Sta. Gives results of experiments in which the ammoniacal solution of copper carbonate mixed with Paris green solution injured the foliage and proved ineffectual against the scab (*Fusicladium dendriticum*). Mixtures of Bordeaux with Paris green proved equally ineffectual. Decides plum wart (*Plowrightia morbosa*), to be controllable by use of kerosene mixed with some bright colored pigment and also kept in check by use of Bordeaux. Gives analysis of 10 pounds of grapes, attached to stems and detached from stems, sprayed vigorously with Bordeaux as showing respectively 0.00996 and 0.00031 pound of copper oxide. Thinks Bordeaux effectual in treatment of mildew and "rot."

216. MCILVAINE, CHAS. **Nature's peasants—Toadstools.** Youths' Companion, February 27, 1890, p. 114 (2 columns with figs.), treats in popular way of edible fungi, giving means of distinction.

217. PAMMEL, L. H. **Some fungus root diseases.** Proc. 11th Ann. Meet. Soc. for Prom. of Agricultural Science, Indianapolis, Indiana, August 1890, pp. 91–94. Gives general account of root diseases with special mention of a sclerotium root disease of *Helianthus annuus* resembling somewhat *Sclerotinia sclerotiorum*. Records experiment with iron sulphate, copper sulphate, chloride of lime, sulphur, and various fertilizers against cotton-root rot which proved wholly unsuccessful. Suggests rotation of crops as best method of dealing with such parasites.

218. PANTON, J. HOYES. **Smut; its habit and remedies.** Bull. LVI, Guelph Agricultural College, Guelph, December 9, 1890. Describes popularly *Tilletia caries* (bunt or stinking smut), *Ustilago carbo* (common or loose smut), recommending as remedies clean seed, copper sulphate 1 pound to 1 gallon of water, caustic potash, 1 pound in 6 gallons of water, brine, and immersion for 5 minutes in water at 135° F. or for 15 minutes in water at 132° F.

219. PATOUILLARD, N. **Fragments mycologique.** Journal de Bot., No. 10, 1890, describes *Ithyphallus cucullatus*, n. s. on the earth, Cambridge, Massachusetts. From herbarium of W. G. Farlow.

220. PECK, C. H. **Wheat smut and its treatment.** Cult. and Country Gent., Albany, New York, October 30, 1890, Vol. LV, No. 1970, p. 855 (2 columns). Describes in popular language the diseases caused by *Ustilago tritici*, *Tilletia fœtens*, and *T. tritici*, giving extract from Bull. 12, Kansas Ag. Ex. Sta., containing description of Jensen hot-water method of treatment. (See 157.)

221. ———. **Potato rot. Bordeaux mixture.** Cult. and Country Gent., Albany, New York, November 30, 1890, Vol. LV, No. 1973, p. 916 (half column). Replies to inquiry about disease, recommending the Bordeaux mixture as remedy against *Phytophthora infestans*, DBy.

222. PEIRCE, GEO. J. **Notes on Corticium Oakesii, B. & C., and Michenera artocreas, B. & C.** (with plate). Bull. Torr. Bot. Club, New York, December 9, 1890, Vol. XVII, No. 12, pp. 301–310. Clears up the question of the method of spore formation in *Corticium Oakesii*, B. & C., deciding the basidial spores to be borne on basidia which are modified and developed paraphyses whose bristles have become larger fewer, longer, and more erect; and the conidial spores to appear upon similar bristles either before or after the formation of basidial spores. Decides the species of *Corticium* to be distinct from *C. amorphum*. Arrives at the conclusion in case of *Michenera artocreas* that a basidial stage does not exist, or is replaced by the conidial stage, which consists of flask-shaped mother cells containing single conidia and provided with flagellate tips.

223. PIERCE, N. B. **The mysterious vine disease.** Thirteenth Ann. Report California State Board of Horticulture, Sacramento, California, pp. 169–177. Compares the disease with *folletage* and *mal nero*, French and Italian diseases which bear a more or less close relation to it. Gives results of field and laboratory investigations, history of the spread and characteristics of the movements of the disease in California. Decides the malady not to be due exclusively to ordinary parasitic vine fungi, giving various views as to the cause of *folletage* and *mal nero*.

224. REX, GEO. A. **Descriptions of three new species of Myxomycetes, with notes on other forms in century XXV of Ellis & Everhart, North American fungi.** Proc. Acad. Nat. Sci., Philadelphia, Part II, April-September, 1890, pp. 192–196. Describes as new *Physarum tenerum*, Rex, No. 2489, N. A. F., *Trichia subfusca*, Rex, No. 2495, *Trichia erecta*, Rex. No. 2496. Gives variations found to exist in *Didymium eximium*, Pk., No. 2493, N. A. F., and No. 2089, N. A. F., and thinks the two specimens distributed under these numbers referable to the above extremely variable species. Redescribes, on account of inadequacy of former descriptions, *Badhamia lilacina*, Fr., No. 2494, N. A. F.

225. ———. **Notes on the development of Tubulina cylindrica and allied species of Myxomycetes.** Bot. Gaz., December 26, 1890, Vol. XV, No. 12, pp. 315–320. Considers the formative plasmodium and subsequent stages in its relation to the systematic study of the *Myxomycetes*, citing various species to show the constancy of color in plasmodia of the same species. Expresses opinion that the color of corresponding stages of development of individual sporangia from plasmodium to maturity is always the same. Supports this view with observations upon *Tubulina cylindrica*, (Bull.), *T. stipitata*, and *Siphoptychium Casparyi*, Rostfki.

226. SCRIBNER, F. L. **The Entomosporium of the pear and quince** (with figs.). Orchard and Garden, Little Silver, New Jersey, September, 1890, Vol. XII, No. 9, p. 166. Discusses use of the word "blight" for the disease, and, together with popular description and notes on distribution, gives as most effective remedy Bordeaux mixture preceded by early treatments with simple solution of copper sulphate.

227. ———. **Leaf spot disease of the plum and cherry** (*Septoria cerasina*, Pk.) (with figs). Orchard and Garden, Little Silver, New Jersey, October 1890, Vol. XII, No. 10, p. 183 (2 columns). Gives popular description of fungus, with recommendation that copper sulphate be used as preventive.

228. ———. **Fungus diseases of grapevines** (with figs.). *Ibid.* With aid of figures, illustrates characteristics of grape leaf-blight, black rot, and anthracnose upon the leaf, quoting results of experiment in treatment of black rot by the Department of Agriculture. (See 195.)

229. ———. **Bean rust** (with figs.). Orchard and Garden, Little Silver, New Jersey, November, 1890, Vol. XII, No. 11, p. 200–201. With excellent illustrations, describes carefully, in popular language, the life-history of *Uromyces phaseoli*. Recommends spraying with copper compounds and destruction of all infected material in the fall.

230. ———. **Beet Rust** (with fig. from Ann. Rep., 1887, U. S. Dept. of Agr.). *Ibid.*, p. 201. Mentions presence of disease as confined, so far as known, to California. Gives life-history, and suggests as remedies iron chloride in dilute solution.

231. ———. **Powdery mildew of the cherry** (with figs.). Orchard and Garden, Little Silver, New Jersey, December, 1890, Vol. XII, No. 12, pp. 210–211. Describes popularly the life-history of *Podosphæra oxyacanthæ*, recommending as preventive fungicide, sulphuret of potassium, one-half ounce to the gallon of water, applied while warm.

232. ———. **Treatment of anthracnose of the vine.** *Ibid.* (quarter column). Quotes formula for treatment from Le Prog. Agricole, October 26, 1890: Water, 3 gallons; iron sulphate, 7 pounds; copper sulphate, 2 pounds; sulphuric acid, 1 gill. Also, powder made by mixing equal parts of Portland cement and sublimated sulphur.

233. ———. **Rose leaf-blight.** *Ibid.* (with figs.). Gives popular description of *Cercospora rosæcola* and effects upon host. Thinks plants placed where air and light are abundant seldom suffer from the disease.

234. ———. **Beet leaf-blight** (with figs.). *Ibid.* Describes *Cercospora beticola* popularly, and recommends clear and open culture as means of lessening liability to disease.

235. SEYMOUR, A. B. **Rose rusts** (with figs.). American Garden, New York, October, 1890, Vol. XI, No. 10, p. 603. Notices *Phragmidium mucronatum* and *Ph. rosæ-alpinæ*, giving distinctions and life-history. Decides *Ph. mucronatum*, var. *Americanum*, Pk., to be identical with *Ph. rosæ-alpinæ*.

236. STEWART, HENRY. **Cotton rust.** American Agriculturist, New York, December, 1890, Vol. XLIX, No. 12, p. 638 (1 column). Denies popular belief that the disease is in any way connected with the growing of clover, and refers it to the attacks of a fungus (name not given).

237. STOKES, A. C. **A fungous parasite of Diatoms** (with figs. redrawn). The Microscope, January, 1891, Vol. XI, No. I, pp. 24–26. Gives an account of a new genus of fungi (*Septocarpus*) described by Kopf in a monograph, as infecting diatoms in subalpine bog-pools of Norway, and translated by Mr. G. C. Karop in Journal of the Quakett Microscopical Club, London. The species of diatom affected was *Pinnularia*, and the fungus is considered distinct from that attacking Desmids.

238. THAXTER, ROLAND. **The potato scab.** Bull. No. 105, Conn. Agrl. Ex. Sta., New Haven, December, 1890, pp. 3, 4. Gives preliminary report upon the disease which has been proved beyond doubt to be connected, as an effect, with an extremely minute fungus resembling, with exception of a branching character, certain polymorphic bacteria. Records careful inoculation experiments which establish connection between the "deep" scab and the fungus, and gives short account of pure cultures in solid culture media. Mentions work in progress upon morphologically identical fungus found commonly upon refuse material.

239———. **On certain new and peculiar North American Hyphomycetes, I.** (with Plates III and IV), Bot. Gaz., Jan. 15, 1891, pp. 14, 26. Enumerates with valuable notes the American species of the genera *Œdocephalum*, Preuss, as *Œ. glomerulosum* Bull.) Sacc., *Œ. echinulatum*, n. s., *Œ. verticillatum* n. s., *Œ. pallidum* (B. and Br.) Cost. Considering *Œ. elegans*, Preuss, as distinct from *Œ. glomerulosum* and *Œ. roseum*, Cook, as a synonym. Decides *Rhopalomyces pallidus*, B. and Br. and *R. candidus*, B. and Br. to be identical and synonyms of *Œ. pallidum*; and *Haplotrichum fimetarium*, Riess., as also a synonym of the same species. Gives *Rhopalomyces elegans*, Corda, *R. cucurbitarum*, Berk. & Rav., *R. strangulatus*, n. s., as known American members of the genus, and descibes a new genus, *Sigmoideomyces*, upon the species *S. dispiroides*, found upon under side of a moist log, Burbank, east Tennessee. Notes that the genus bears much the same relation to *Œdocephalum* that *Dispira* does to *Aspergillus*. Closes with synopsis of the described species of *Œdocephalum* and *Rhopalomyces*.

240. WEED, C. M. **The scab of wheat heads.** Proc. 11th Ann. Meeting, Society for the Promotion of Agricultural Science, Indianapolis, Indiana, August 18, 19, 1890, pp. 47–48 (issued December, 1890, with figs.). Notes *Fusisporium culmorum*, W. G. Smith, as causing serious damage to the heads of wheat in Ohio.

241. ———. **A second experiment in preventing the injuries of potato blight.** Bull. Ohio Ag. Ex. Sta., second series, Vol. III, No. 8, September, 1890. Gives report of somewhat unsatisfactory experiments against potato blight with use of Bordeaux and ammoniacal copper carbonate solutions. Notes bacterial disease as found by Burrill in Illinois.

242. WINGATE, HAROLD. **Orcadella operculata, Wing. Nouveau Myxomycete.** Revue Mycologique, Toulouse, April, 1890. (November, 1889), No. 46, p. 74. Describes a new family of *Myxomycetes* (*Orcadellaceæ*) consisting of the single species *Orcadella operculata*, found in Fairmount Park, Philadelphia, and also in Maine (Harvey), growing on living trunks of *Quercus rubra*. Considers it to stand in order 4 of Rostafinski after family 13 (*Clathroptychiaceæ*) and unites in a measure the orders *Anemeæ* and *Heterodermieæ*.

GENERAL INDEX.

INDEX TO FUNGI.

[NOTE.—Fungi described in the text are in small capitals, synonyms in italics.]

INDEX TO HOSTS.

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